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THE COMPUTATION OF THE MOMENT OF INERTIA OF A GIRDER BY RECTANGULAR COMPONENTS.

By ROBERT BRIGGS and LUIGI D'AURIA.

The usual method of computing the moment of inertia of a girder around its neutral axis is first to lay off the section into rectangular surfaces whose several centres of gravity are supposed to be crossed by lines parallel to the axis of the system which passes through the common centre of gravity. An axis is assumed, and the distances from this axis to centers of the rectangular components is then taken; when the sum of those distances on the one side of the axis, multiplied into the surfaces, will be compared with the sum of the distances on the other side of the axis multiplied into the corresponding surfaces, and by trial of new axes, finally these two sums will be made equal, when the axis thus determined will be the true neutral axis of the system. Then, to obtain the moment of inertia of the system, the well-known rule of procedure is to take the sum of the moments of the several rectangular components referred to their own neutral axes by by the formula. $I = \frac{1}{12} bh^3$ (where I = moment of inertia, b = breadth and h = height of the section), to which sum is added the sum of the squares of the distances, of the several component axes

from the general axis of the system, multiplied by the surfaces respectively.

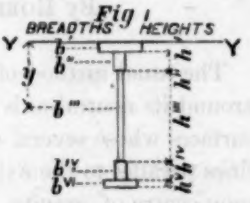
For a girder composed of a small number of components, there is to be found in most text books some formula which will give an accurate result, with possibly a few less figures than is required for the detailed estimate above described; but the application of these formulæ becomes a blind following to any who are not fresh in the exact method by which these formulæ were derived, and generally the application of such formulæ cannot be extended to beyond three, or at most five, components.

The writer of this note was engaged in laborious computing the common centre of gravity and moment of inertia of a girder after the methods described, when he asked the assistance of Prof. D'Auria to test his calculations. The methods followed by the latter were found to present some novelty in symmetric arrangement and convenience in application in general for any number of components, such as to warrant publication.

The position of centre gravity in a surface composed of a system of rectangular components is given as follows:

The line $\overline{YY}$ is taken as the origin,
$\therefore b$ = respective breadths,
h = respective lenghts of sides of each section,
y = distance of line of centre of gravity from $\overline{YY}$.

Fig 1



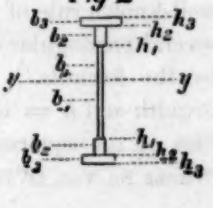
$$\therefore y = \frac{\text{sum of moments of surfaces from } \overline{YY}}{\text{area of surfaces}} =$$

$$\frac{b_1 h^{i}(\frac{1}{2}h^{i}+0)+b_2 h^{ii}(\frac{1}{2}h^{ii}+h^{i})+b_3 h^{iii}(\frac{1}{2}h^{iii}+h^{ii}+h^{i})}{b_1 h^{i} \quad + \quad b_2 h^{ii} \quad + \quad b_3 h^{iii}} \quad . \quad (I)$$

The moment of inertia referred to the line of centre of gravity (y, as above found) can thus be ascertained as follows:

The line $\overline{yy}$ is taken as the neutral axis,
$\therefore b$ = respective breadths,
h = respective distances from the neutral axis,
I = moment of inertia,
Z = general value for h.

Fig 2



$$\therefore I = b_1\int_0^{h_1} z^2dz + b_2\int_{h_1}^{h_2} z^2dz + b_3\int_{h_2}^{h_3} z^2dz + \ldots\ldots b_n\int_{h_{n-1}}^{h_n} z^2dz$$

$$+ b_{-1}\int_0^{h_{-1}} z^2dz + b_{-2}\int_{h_{-1}}^{h_{-2}} z^2dz + b_{-3}\int_{h_{-2}}^{h_{-3}} z^2dz + \ldots\ldots b_{-n}\int_{h_{-(n-1)}}^{h_{-n}} z^2dz \quad \text{(II)}$$

and integrating between limits

$$I = \tfrac{1}{3}\left[b_1h^3_1 + b_2h^3_2 - b^2h^3_1 + b_3h^3_3 - b_3h^3_2 + \ldots\ldots b_nh^3_n - b_nh^3_{n-1}\right.$$

$$\left. + b_{-1}h^3_{-1} + b_{-2}h^3_{-2} - b_{-2}h^3_{-1} + b_{-3}h^3_{-2} + \ldots\ldots b_{-n}h^3_{-n} - b_{-n}h^3_{-(n-1)}\right] \text{(III)}$$

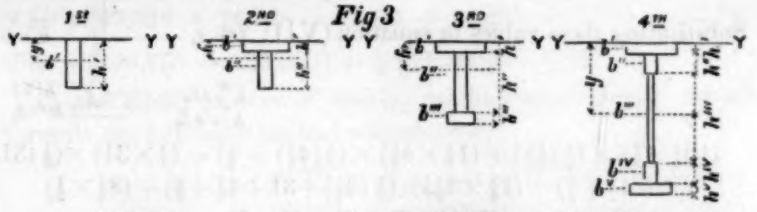
$$I = \tfrac{1}{3}\left[h^3_1(b_1 - b_2) + h^3_2(b_2 - b_3) + h^3_3(b_3 - b_4) + \ldots h^3_{n-1}(b_{n-1} - b_n) + h^3_nb_n\right.$$

$$+ h^3_{-1}(b_{-1} - b_{-2}) + h^3_{-2}(b_{-2} - b_{-3})\, h^3_{-3}(b_{-3} - b_{-4}) + \ldots\ldots$$

$$\left. h^3_{-(n-1)}(b_{-(n-1)} - b_{-n}) + h^3_{-n}b_{-n}\right] \quad \text{(IV)}$$

The symmetrical form of these equations allow any number of values to be taken. For convenience of reference, the following examples are exhibited: Formulæ for position of neutral axis $= y$.

Fig 3



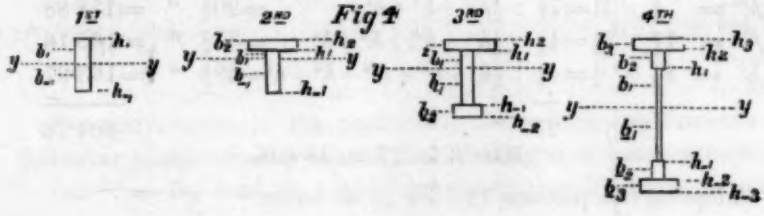
$$\text{1st. } y = \frac{b_1h^i\left(\frac{1}{2}h^i\right)}{b_1h^i} = \tfrac{1}{2}h^i \quad \text{2d. } y = \frac{b_1h^i\left(\frac{1}{2}h^i\right) + b_2h^{ii}\left(\frac{1}{2}h^i + h^{ii}\right)}{b_1h^i + b_2h^{ii}} \quad \text{(V)}$$

$$\text{3d. } y = \frac{b_1h^i\left(\frac{1}{2}h^i\right) + b_2h^{ii}\left(\frac{1}{2}h^{ii} + h^i\right) + b_3h^{iii}\left(\frac{1}{2}h^{iii} + h^{ii} + h^i\right)}{b_1h^i + b_2h^{ii} + b_3h^{iii}} \quad \text{(VI)}$$

$$\text{4th. } y = \frac{\begin{array}{l} b_1h^i\left(\frac{1}{2}h^i\right) + b_2h^{ii}\left(\frac{1}{2}h^{ii} + h^i\right) + b_3h^{iii}\left(\frac{1}{2}h^{iii} + h^{ii} + h^i\right) + b_4h^{iv}\left(\frac{1}{2}h^{iv} + h^{iii}\right. \\ \left. + h^{ii} + h^i\right) + b_5h^v\left(\frac{1}{2}h^v + h^{iv} + h^{iii} + h^{ii} + h^i\right) \end{array}}{b_1h^i + b_2h^{ii} + b_3h^{iii} + b_4h^{iv}b_5h^v} \quad \text{(VII)}$$

Formula for moment of inertia $= I$

Fig 4



1st. Where $b_1 = \underset{-1}{b}$ and $h_1 = \underset{-1}{h}$; $I = \frac{1}{3}\left[h^3_1 b_1 + \underset{-1}{h^3}\,\underset{-1}{b}\right] = \frac{2}{3}(h^3_1 b_1)$ (VIII)

(If we take $h_1 = \frac{h}{2}$ when h = total height of beam then from VIII, $I = \frac{2}{3}\left(\frac{h}{2}\right)^3 b_1 = \frac{1}{12}\, h^3 b_1$, which is the usual formula given for the moment of inertia of this section.)

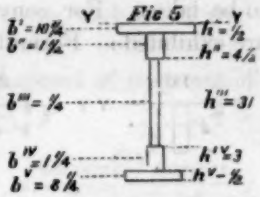
2d. $I \frac{1}{3}\left[h^3_1 (6_1 - 6_2) + h^3_2 b_2 + \underset{-1}{h^3}\,\underset{-1}{6}\right]$. (IX)

3d. $I = \frac{1}{3}\left[h^3_1 (b_1 - b_2) + h^3_2 b_2 + h^3_1 (\underset{-1}{b} - \underset{-2}{b}) + \underset{-2}{h}\,\underset{-2}{b}\right]$. (X)

4th. $I = \frac{1}{3}\left[h^3_1 (b_1 - b_2) + h^3_2 (b_2 - b_3) + h^3_3 b_3 + h^3_{-1} (\underset{-1}{b} - \underset{-2}{b}) + h^3_{-2} (\underset{-2}{b} - \underset{-3}{b}) + h^3_{-3}\,\underset{-3}{b}\right]$ (XI)

A numerical example of the 4th proposition, formulæ VII and XI, is given below.

Fig 5



Substituting these values in equation (VII)

$$y = \frac{\begin{array}{c}(10\frac{1}{4}\times\frac{1}{2})\times(\frac{1}{2}(\frac{1}{2}))+(1\frac{1}{4}\times4\frac{1}{2})\times(\frac{1}{2}(4\frac{1}{2})+\frac{1}{2})+(\frac{1}{4}\times31)\times(\frac{1}{2}(31)\\ +4\frac{1}{2}+\frac{1}{2})+(1\frac{1}{4}\times3\frac{1}{2})\times(\frac{1}{2}(3\frac{1}{2})+31+4\frac{1}{2}+\frac{1}{2})+(8\frac{1}{4}\times\frac{1}{2})\\ \times(\frac{1}{2}(\frac{1}{2})+3\frac{1}{2}+31+4\frac{1}{2}+\frac{1}{2})\end{array}}{10\frac{1}{4}\times\frac{1}{2}+1\frac{1}{4}\times4\frac{1}{2}+\frac{1}{4}\times31+1\frac{1}{4}\times3\frac{1}{2}+8\frac{1}{4}\times\frac{1}{2}}$$

$$y = \frac{5\frac{1}{8}\times\frac{1}{4}+5\frac{5}{8}\times2\frac{3}{4}+7\frac{3}{4}\times20\frac{1}{2}+4\frac{3}{8}\times37\frac{3}{4}+4\frac{1}{8}\times39\frac{3}{4}}{5\frac{1}{8}+5\frac{5}{8}+7\frac{3}{4}+4\frac{3}{8}+4\frac{1}{8}}$$

$$y = \frac{1{\cdot}28+15{\cdot}47+158{\cdot}88+165{\cdot}16+163{\cdot}97}{27{\cdot}} = 18{\cdot}695$$

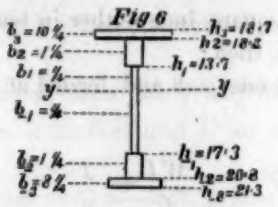
A tabular method of computing formula (VII) is as follows:

$b_1 h^{\mathrm{i}}$	$= 10\frac{1}{4}\times\frac{1}{2} = 5\frac{1}{8}$:	$\frac{1}{2}h^{\mathrm{i}}$	$= \frac{1}{4}\times\varphi bh = 1{\cdot}28$
$b_2 h^{\mathrm{ii}}$	$= 1\frac{1}{4}\times4\frac{1}{2} = 5\frac{5}{8}$:	$\frac{1}{2}h^{\mathrm{ii}}+h^{\mathrm{i}}$	$= 2\frac{3}{4}$ " $= 15{\cdot}47$
$b_3 h^{\mathrm{iii}}$	$= \frac{1}{4}\times31 = 7\frac{3}{4}$:	$\frac{1}{2}h^{\mathrm{iii}}+h^{\mathrm{ii}}+h^{\mathrm{i}}$	$= 20\frac{1}{2}$ " $= 158{\cdot}88$
$b_4 h^{\mathrm{iv}}$	$= 1\frac{1}{4}\times3\frac{1}{2} = 4\frac{3}{8}$:	$\frac{1}{2}h^{\mathrm{iv}}+h^{\mathrm{iii}}+h^{\mathrm{ii}}+h^{\mathrm{i}}$	$= 37\frac{3}{4}$ " $= 165{\cdot}16$
$b_5 h^{\mathrm{v}}$	$= 8\frac{1}{2}\times\frac{1}{2} = 4\frac{1}{8}$:	$\frac{1}{2}h^{\mathrm{v}}+h^{\mathrm{iv}}+h^{\mathrm{iii}}+h^{\mathrm{ii}}+h^{\mathrm{i}}$	$= 39\frac{3}{4}$ " $= 163{\cdot}97$
	27		$504{\cdot}76$

$504{\cdot}76 \div 27 = 18{\cdot}695.$

Adopting this position 18·7 for $\overline{yy}$ we have:

Fig 6



Substituting these values in equation (XI)

$$I = \tfrac{1}{3}\,[(13{\cdot}7)^3 \times (\tfrac{1}{4}-1\tfrac{1}{4}) + (18{\cdot}2)^3 \times (1\tfrac{1}{4}-10\tfrac{1}{4}) + (18{\cdot}7)^3 \times 10\tfrac{1}{4} + (17{\cdot}3)^3 \times (\tfrac{1}{4}-1\tfrac{1}{4}) + (20{\cdot}8)^3 \times (1\tfrac{1}{4}-8\tfrac{1}{4}) + (21{\cdot}3)^3 \times 8\tfrac{1}{4}]$$

$$I = \tfrac{1}{3}\,[(13{\cdot}7)^3 \times -1 + (18{\cdot}2)^3 \times -9 + (18{\cdot}7)^3 \times 10\tfrac{1}{4} + (17{\cdot}3) \times -1 + (20{\cdot}8)^3 \times -7 \times (21{\cdot}3) \times 8\tfrac{1}{4}]$$

$$I = \tfrac{1}{3}\,[2{,}571 \times -1 + 6{,}029 \times -9 + 6{,}539 \times 10{\cdot}25 + 5{,}178 \times -1 + 8{,}999 \times -7 \times 9{,}664 \times 8{\cdot}25]$$

$$I = \tfrac{1}{3}\,[6{,}539 \times 10{\cdot}25 + 9{\cdot}664 \times 8{\cdot}25 - (2{,}571 + 6{,}029 \times 9 + 8{,}178 + 8{,}999 \times 7)]$$

$$I = \tfrac{1}{3}\,[67{,}025 + 79{,}728 - (2{,}571 + 54{,}261 + 5{,}178 + 62{,}993)]$$

$$I = \tfrac{1}{3}\,[146{,}753 - 125{,}003] = \tfrac{1}{3}\,[21{,}750] = 7{,}250$$

In the actual practice of making up the computation of the above formula the following method was adopted:

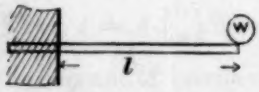
	$\phi\, b$		3d power of h × by $\phi\, b$		
				—	+
$b_1 - b_2 =$	$\frac{1}{4} - 1\frac{1}{4} =$	-1 ; $h_1 = 13{\cdot}7$	2,571	2,571	
$b_2 - b^3 =$	$1\frac{1}{4} - 10\frac{1}{4} =$	-9 ; $h_2 = 18{\cdot}2$	6·029	54,261	
b_3	=	$10\frac{1}{4}$; $h_3 = 18{\cdot}7$	6·539		67·025
$b_{-1} - b_{-2} =$	$\frac{1}{4} - 1\frac{1}{4} =$	-1 ; $h_{-1} = 17{\cdot}3$	5,178	5,178	
$b_{-2} - b_{-3} =$	$1\frac{1}{4} - 8\frac{1}{4} =$	-7 ; $h_{-2} = 20{\cdot}8$	8,999	62,993	
b_{-3}	=	$8\frac{1}{4}$; $h_{-3} = 21{\cdot}3$	9,664		79·728
				125,003	146,753
					125,003
					3) 21,750
					7,250

For convenience in the application of the foregoing formulæ the following additional ones relating to the strength of beams are quoted.

Let W = the load on a beam in pounds, l = its length in inches,

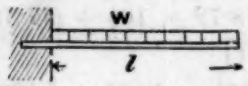
f = the strength per square inch (either in tension or compression) of the material employed, then:

For a beam fixed at one end and loaded at the extreme end with a load = W



$$\frac{W l}{f} = \frac{I}{y} \qquad \text{(XII)}$$

For a beam fixed at one end with load uniformly distributed on its length = W, when $w\,l = W$

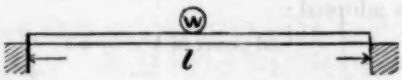


$$\frac{W\frac{l}{2}}{f} = \frac{I}{y} \quad \therefore \quad \frac{w\frac{l^2}{2}}{f} = \frac{I}{y} \qquad \text{(XIII)}$$

For a beam fixed at one end with a load uniformly distributed on its length = w, and an additional load = W at its extreme end

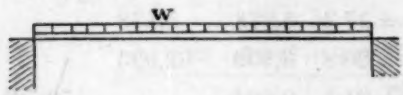
$$\frac{W l + w\frac{l^2}{2}}{f} = \frac{I}{y} \qquad \text{(XIV)}$$

For a beam supported at both ends with a single load = W in the middle of its length



$$\frac{W\frac{l}{4}}{f} = \frac{I}{y} \qquad \text{(XV)}$$

For a base supported at both ends with load uniformly distributed on its length = w, when $w\,l = W$



$$\frac{W\frac{l}{8}}{f} = \frac{I}{y} \quad \therefore \quad \frac{w\frac{l^2}{8}}{f} = \frac{I}{y} \qquad \text{(XVI)}$$

For a beam supported at both ends with a load uniformly distributed on its length = w, and an additional load = W in its middle

$$\frac{W\frac{l}{4} + w\frac{l^2}{8}}{f} = \frac{I}{y} \qquad \text{(XVII)}$$

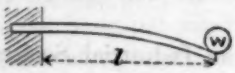
Other conditions must be computed for, but most cases can be considered, approximately at least, by the above.

A suddenly applied load must be considered as exerting double the force of a permanent pressure. The affect of a rolling load, like that

of a railway train, being intermediate with that of a permanent and a suddenly applied load.

The deflection of beams under loads may be computed in the following cases when $\overline{s}$ = deflection and E = modulus of elasticity of the material.

Beams of uniform cross section.—For a beam fixed at one end and loaded at extreme end with a load = W

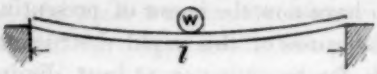


$$\overline{s} = \tfrac{1}{3}\,\frac{W l^3}{E I} \qquad \text{(XVIII)}$$

For a beam fixed at one end, uniformly loaded

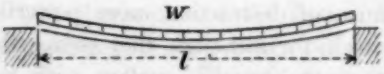
$$\overline{s} = \tfrac{1}{8}\,\frac{W l^3}{E I} \qquad \text{(XIX)}$$

For a beam supported at both ends, loaded in middle



$$\overline{s} = \tfrac{1}{48}\,\frac{W l^3}{E I} \qquad \text{(XX)}$$

For a beam supported at both ends, uniformly loaded



$$\overline{s} = \tfrac{5}{384}\,\frac{W l^3}{E I} \qquad \text{(XXI)}$$

Other cases of deflection become too complicated to be presented in this attempt to give a practical form to these computations.

Railway in Palestine.—A French company has secured the privilege of constructing a railroad in the interior of Palestine. It may be valuable for strategic purposes, and it will undoubtedly develop the commercial resources of the country. The greatest obstacle to the introduction of factories and workshops has been the want of fuel. Egypt, Syria and the coasts of the Red Sea are destitute of wood, and the imported coal commands from 150 to 200 francs ($30 to $40) a ton. The asphalt of the Dead Sea indicates probable subterranean deposits of fossilized vegetable matter, and evidences of inexhaustible beds of lignite have been found. The lignite and asphalt can be easily combined in briquettes, at a cost of from 12 to 25 francs ($2.40 to $5.00) per ton.—*Les Mondes.* C.

ON THE CORROSION OF PLATE-IRON FEED WATER HEATERS FOR STEAM-BOILERS.

A Note presented by Messrs. Auguste Scheurer-Kestner and Charles Meunier-Dolfus to the "Industrial Society of Mulhouse" at its sitting of May, 1871.

Translated by Chief Engineer ISHERWOOD, United States Navy.

The articles published in the Bulletins of the Industrial Society during several years, and particularly the report made in 1862 by Mr. Burnat of experiments with different boilers, led to the extensive use of feed water heaters placed in the brick flue through which the gases of combustion proceed from the boiler to the chimney. Unfortunately the well-established benefit of these heaters, as regards economy of fuel, is diminished in certain cases by their very rapid destruction.

We propose in the note which we have now the honor of presenting to the Industrial Society to state the causes of this rapid destruction, and the experiments we have made for removing or, at least, diminishing them.

The heaters are subjected to causes of destruction more powerful than those which attack the boiler itself, for although they escape the danger resulting from the contact of the metallic surface with the furnace flame, they are nevertheless more quickly destroyed than are the parts of the boiler the most exposed to the fire. Our remarks apply exclusively to plate-iron heaters, and not to those of cast iron which, owing to the nature of the latter metal, better resist the chemical action.

The object of employing a heater is to reduce the temperature of the gases of combustion to the lowest limit compatible with a sufficient chimney-draft, so that no more heat may escape with them than is indispensable for their necessary ascensional velocity. The cooling of these gases, however, is sometimes thus carried below the point intended,* when it acts injuriously.

1st. By the too great diminution of the draught.

2d. By the deterioration of the metallic surfaces of the heater.

We have nothing special to add to what is already well known

* We have found the temperature of the gases of combustion when leaving the heater to be sometimes below 212° Fahrenheit.

regarding the disadvantages of an insufficient draught. We will merely remark that the use of a heater not only reduces the draught by the resulting lessened temperature of the gases of combustion, but far more by the several right-angled turns it causes in the flue containing it, and by the friction of these gases on its surfaces and on those of the flue.

The deterioration of the metallic surfaces of boilers takes place on the inside and on the outside, but the chemical agents which act on them have not much strength. This is not the case, however, with the heaters, which are exposed to corrosion interior and exterior, with the further danger of being burnt if, through bad design, masses of air or vapor collect in them at different points, as often happens at the bends joining the pipes of the heater or connecting it with the boiler. The communication between two pipes of a heater should be so made that the semicircular bend or connecting part commences at the highest point of the lower pipe and ends at the lowest point of the upper pipe; in the same manner, the connection joining the heater to the boiler should start from the highest point of the upper pipe of the heater.

Interior Corrosion.

The destruction of the iron of the interior surface of a heater is a phenomenon of oxidation; *the iron rusts:* that is to say, it combines with oxygen and is transformed into oxide of iron. This oxygen is not obtained from the decomposition of the water, but from the air which the water holds in solution: and the oxidation is so singularly promoted by the presence of carbonic acid that the rapidity of the corrosion has been found to depend on the nature and quality of the water.

When a heater is examined after several months' use with water made corrosive by the presence of carbonic acid, the interior surface is found covered with a thick coat of ochrous powder forming mushroom-like appearances. The rivets seem to be more attacked than the plate-iron, and their heads are sometimes entirely rusted off while the plate-iron is affected to the depth of only the $\frac{4}{1000}$ of an inch. This ochrous powder effervesces with acids, and contains a mixture of carbonate and of oxide of iron, a composition that well corresponds to the mode of its formation as described above.

Why is not this corrosion observed or, at most, to only a very small extent, in the interior of the boiler? Because this particular kind of

attack on the iron is not made at high temperatures, and results from the fact that the dissolved oxygen alone acts while the water is simply its vehicle. The feed water on entering a boiler in operation is immediately raised to a temperature at which the dissolved oxygen disengages and ascends into the steam room, where it is harmless. In a heater, on the contrary, the feed water is so slowly raised in temperature that its dissolved oxygen can act on the iron; the water in its passage through the heater does indeed lose this oxygen, but, instead of escaping with the steam, it combines with the iron, which it transforms to rust. This is the reason why those parts of the heater that are the farthest from the boiler and the nearest to the check-valve are the most attacked, and why the parts that precede them are less and less attacked as they are nearer and nearer to the boiler.

The nature and quality of the water have a considerable influence on the rapidity of these phenomena of oxidation. Calcareous water which, on losing its carbonic acid, precipitates its carbonate of lime, is accompanied by a slower oxidation; the calcareous salts, by settling on the metal, cover it with a protecting coat that shields it from an interior attack; thus, the earthy matters which are so injurious to the boiler are the preservation of the heater, while the non-calcareous water that spares the boiler destroys the heater by oxidation. The water from the hot-well of engines, when not earthy, forms the best feed for the preservation of boilers, because it has been deprived by its elevated temperature of a portion of its dissolved carbonic acid and oxygen; but if it be calcareous or magnesian, the fatty matter derived from the lubrication of the cylinders, by mingling with those salts, often causes fatty-earth precipitates upon the metallic surfaces of the boiler, and exposes them to being burnt if the temperature is sufficiently high at such places.

The following experiments, which we made with three kinds of water, show strikingly their mode of action upon iron. Three flasks, containing 610 cubic inches each, were filled with three kinds of water to be tried.

The first contained water from the granite rocks of the valley of Saint Amarin, free of calcareous salts but well aerated.

The second contained calcareous water from Jurassic earth, equally well aerated and containing carbonic acid.

The third contained distilled water, recently boiled to expel all the oxygen.

The flasks having been filled to the neck, and the usual precautions in such cases having been taken for preventing the contact of air with the water in the third flask, they were closed by cork stoppers so as to leave no space between the water and the stoppers. Through the centre of the cork stopper a clean and polished iron wire was forced until it touched the bottom of the flask. The stoppers being now sealed, the three flasks were left for several weeks, and the following are the observations made:

Flask No. 1 (water not calcareous) showed the commencement of oxidation. Some yellowish strips or striæ soon formed ridges on the bottom of the flask by running down from the wire, which little by little became covered with rust resembling mushrooms in appearance. When all the oxygen of the water was consumed the phenomena of oxidation ceased; and the wire withdrawn from the flask, cleaned and replaced, remained bright as if it was varnished.

Flask No. 2 (water calcareous) showed the same phenomena of oxidation, but they appeared much more slowly, and the yellowish striæ were mixed with the white striæ of the precipitated calcareous salts. At the end of some time, the wire having been withdrawn, cleaned and replaced, was again covered with a fresh coat of ochre. The calcareous salts, by their deposition upon the metal, had opposed and retarded its oxidation.

Flask No. 3 (distilled water free of air) showed no phenomena of oxidation. The wire remained bright in it.

These experiments require no commentary, and they give an exact idea of what occurs inside of heaters.

Exterior Corrosion.

The gases of combustion destroy the iron of the exterior surface of heaters. These gases contain the vapor of water and the vapors of the compound acids, of which the sulphurous and sulphuric form the principal portion.* As long as there is no condensation on the metallic surface the acids are harmless, experience having shown that hot acids, even in the presence of aqueous vapor, have but little or no action on

* The gaseous products of the combustion of coal contain a considerable quantity of aqueous vapor. Coal containing from four to five per centum of hydrogen produces by its combustion from thirty-six to forty-five per centum of its weight of aqueous vapor, which is carried along with the smoke. The hygrometric water of the coal also adds to this vapor.

iron raised to a certain temperature. This is also the reason why these gases and acid vapors have so little effect upon the shell of the boiler. The pipes of the heater nearest the boiler suffer a little more, but the cold ones farthest removed are quickly attacked. The latter become covered with drops of the water of condensation in which the sulphurous acid dissolving in the presence of iron changes to sulphuric acid that attacks the metal.

When a heater is examined which has been in use during several months, yellow crusts, composed of very basic sulphate of iron and oxide of iron, are found upon its outside surface. The attack on the exterior surface takes place especially at the angles and edges of the plate-iron where water can lodge.

As the interior corrosion was greatly influenced by the quality of the water, so the rapidity of the exterior corrosion depends on the quality of the coal. Coal containing large quantities of sulphur causes a very prompt destruction of the outside surface of the heater; while, on the contrary, coal free of sulphur leaves it nearly intact. Although coal contains generally but little sulphur, yet the influence of the resulting sulphurous acid in its gases of combustion has been remarked under other circumstances. One of our colleagues, Mr. Bruckner, two years ago called attention to the formation of sulphate of alumina on the tiles of our manufactories, the sulphur element of which could have been furnished only by the gases of combustion escaping from their chimneys.

The condensation on the other metallic surfaces of the heater, and consequently their corrosion, depends much less on the temperature of the gases of combustion in contact with them than on that of the water in contact with the inner surfaces; and although in practice there is a nearly constant proportion between these temperatures, yet the condensation is almost always accompanied by a considerable cooling of the gases; nevertheless, the condensation of the aqueous vapor can take place even in the mass of hot gases by reason of the heat-conductibility of the iron. If a heater contains cold water, its exterior surface, though immersed in a very hot atmosphere, will have a temperature differing but very little from that of the water; consequently, condensation always takes place on the surface enclosing the water. Some years since Mr. Henri St. Clair Deville made an experiment that throws light on the action of a metallic surface placed between a cold liquid and a hot gas. Having coated the exterior of a platinum tube

with the tincture of turnsol, he passed a rapid stream of water through it and plunged it in the midst of a gas heated to the temperature of bluish-red; the tincture of turnsol, which decomposes at the temperature of 392 degrees Fahr., remained intact.

It thus appears that the corrosion of the exterior surfaces of heaters is principally induced by the low temperature of the water within them, and as the same conclusion applies to the corrosion of the interior surfaces, we have an explanation why the heater is attacked so much more promptly than the boiler.

We will now cite some cases which have fallen under our observation, in order to give an idea of the extent of the injury that can be produced, and will then relate the experiments we have made for the purpose of finding a remedy.

The factory of Mr. Kestner, at Thann, contained six heaters,* having three returns of the current of the gases of combustion which flowed in an opposite direction to that of the water in the heaters; the feed-water was constantly cold, and the temperature of the gases of combustion on emerging from the heaters varied from 194 to 320 degrees Fahr. This apparatus was erected in December, 1866, and was worked day and night. In February, 1869, the two lower pipes of the heaters required repairs. They were greatly corroded on the inside and outside, while, in certain parts, particularly at the joints, the metal had lost 0·008 of an inch of its original thickness. The upper pipes were but little affected. In the lowest pipe the water had a mean temperature of 59 degrees Fahr., and in the next lowest of 86 degrees. The third pipe above the lowest contained water at 104 degrees Fahr. and was much less attacked. The fourth, with water at 122 degrees was scarcely affected. It is remarkable to find theory confirmed in this manner on such a point, for it is known that water between the temperatures of 104 and 122 degrees Fahr. loses the oxygen held in solution.

The exterior corrosion follows the same gradation and appears much diminished in a heater containing water at 104 degrees Fahr.

By feeding boilers, therefore, with water previously heated to 86

* These six heaters were connected to two boilers. During a certain time only one of the boilers being in use and all the heaters being used with it, there was a very rapid destruction of the interior and exterior surfaces of the heaters, notwithstanding the small consumption of coal, which was only 1984 pounds of Ronchamp per day and 1322 pounds per night.

degrees Fahr., as is the case with that which comes from the hot-well of steam engines, the chances of the destruction by corrosion of the interior and exterior surfaces of heaters are considerably diminished.

The number of pipes composing heaters increases their chances of corrosion. We have seen that cold water fed to boilers remains harmless, because being immediately heated by mixture with great quantities of water at a high temperature, its dissolved oxygen is disengaged and passes off with the steam. Now if a heater, instead of being formed of six pipes, in which a mixing of the hot and cold waters is not possible, was formed of only one or two pipes, a mixing could evidently take place in it, and a great part of the oxygen, if not the whole, would be disengaged in the gaseous state. But in this case, care must be taken to provide the pipes with such outlets as would prevent the collection of gaseous matter in their upper parts which would expose the metal to burning by the hot gases of combustion.

Two heaters erected in the factory of Mr. Kestner in 1862, and connected with two boilers, have been in use day and night during six years without repairs. Although the water in the lower pipe was at 104 degrees Fahr., yet, at the end of this time, the interior and exterior corrosions were so deep that it had to be renewed. In these two heaters, whose duration was double that of the one previously described, the cold water was always mixed with a large quantity of water at 104 degrees Fahr., from which resulted a diminution of the destructive action of the water, and also of the condensation on the exterior surfaces.

Similar facts have been observed during several years in other factories. "The Alsatian Association of the owners of steam boilers" have renewed twenty heaters in a single year. The age of these apparatus varied from five to eight years of day service.

We have attempted the protection of the interior metallic surfaces of the two lower pipes of heaters by the application of paint or tar. This diminished the corrosion which may possibly be prevented by constant renewal of the coating.

With the view of protecting the heaters against exterior corrosion, we have tried the application of paint to the outside of the lower tubes, but it did not resist the acid condensation nor the heat of the gases. We succeeded better by tinning part of one of the lower tubes. After remaining six months in the flue, the tinned part of this tube, in which the temperature of the water was never higher than 86 degrees Fahr.,

was found perfectly preserved. The temperature of the gases of combustion, when emerging from this heater, never exceeded 392 degrees Fahr.

Finally, considering the great disadvantages of plate iron when its opposite surfaces are exposed to the action of cold water and an acid atmosphere, we experimented with copper. Another part of the heater was encircled by a band of copper 0·008 inch thick, closely applied with its edges bolted together. After six months it was found pierced by corrosion with innumerable holes and transformed in great part into basic sulphate of copper. Under these conditions, the copper did not resist the action of the sulphurous Ronchamp coal.

From the preceding facts appear that the remedy for the evils resulting from too cold a feed-water or from too great a cooling of the smoke, is the painting of the interior surfaces of the lower pipes * of the heater and the tinning of their exterior surfaces.

In the manufacture of new heaters, designs should be adopted which admit the use of cast iron instead of plate iron, as cast iron better resists the action of gaseous acids. We have observed those cast iron bends of the heaters which are not covered by the masonry, and are therefore exposed to the gaseous current, are vastly less attacked than the plate iron. The difference is due to two causes: first, the nature of the metal itself; second, its greater thickness, which by keeping the exterior surface at a higher temperature render the condensation less copious. A long experience confirms this opinion, for cast iron heaters erected many years ago in Alsace have resisted the influences we have described.

Be that as it may, the advantage of even plate iron heaters of large diameter of pipe, as regards economy of fuel, is much greater than the cost of making and repairing them, in proof of which we need only cite the boilers mentioned above, the heaters of which were in the most favorable condition for destruction, and in the least favorable condition for economic effect by reason of a very small daily consumption of coal.

The consumption of coal having been 647 tons per year (mean of three years), and the economy produced by the heaters eight per

* We are here speaking of only plate iron pipes of large diameter, in which the circulation of the water is methodical.

centum,* we find their annual saving to be 52 tons of coal, or about $208, at $4 per ton; the price of three heaters for a boiler being about $600, the heaters pay for themselves in three years at most. The daily consumption of coal being generally much greater than the above, the saving effected by the heaters will be correspondingly greater, and the cost of their additional heating surface is rapidly recovered by their economy of coal.

ON THE HISTORY OF ALIZARIN AND ALLIED COLORING MATTERS.

Read before the Chemical Section of the Society of Arts, May 22d, 1879,

By W. H. PERKIN, F.R.S.

It will be interesting to inquire into the commercial results of this industry, and, firstly, what has been its influence upon the sale of madder and its derivatives. The annual value of the imports into the United Kingdom of madder and garancine, from 1859 to 1868, amounted to about £1,000,000, with prices averaging for madder 45s. to 50s. per cwt., and for garancine, 150s. In the subjoined table will be seen the remarkable changes that have taken place in the imports, and also the great reduction in price:

Average Annual Imports of Madder and Garancine into the United Kingdom and prices.

Year.	Madder. cwts.	Garancine. cwts	French Madder.	Turkey roots.	Garancine.
1859 } 1868 }	305,840	45,560	45s.	50s.	150s.
1875	100,280	25,860	—	—	—
1876	59,137	15,396 } or 6,436 }	—	—	—
1877	38,711	8,875	—	—	—
1878	32,990	2,790	18s.	17s.	65s.

*The economy of these heaters has been determined not only by observation of the elevation of temperature they produce in the feed-water, but also by comparative experiments on boilers functioning with and without them during periods of several weeks.

Up to and during 1876 considerable quantities of artificial alizarin were imported from the Continent and entered at the Customs as garancine or madder, which, having been brought to the notice of the officials, the returns made subsequently are more reliable. The imports of garancine were returned by the Board of Trade in 1876 as 15,396 cwts. when first published, but in the following year, when the figures for 1876 were given for comparison with those of 1877 and 1878, the returns were stated as only 6,436 cwts. The erroneous entries were most probably made to evade the penalties for the infringement of patent rights.

Dutch ground madder has been relatively much higher in price than the other qualities. This is owing to its extensive use in wool dyeing. For various reasons artificial alizarin has made but little progress in its application to wool dyeing, and Dutch madder being mostly used for this purpose, its prices have been maintained at from 28s. for ordinary "Ombro" to about 40s. to 45s. for crop madder. The wool dyers have, however, been working cautiously with artificial alizarin, and now some of them are using it somewhat largely, and considering its cheapness as compared with Dutch madder, no doubt they will soon find how to use it successfully and cease to employ madder.

The decline in the sale of madder is still rapidly going on. During the first two months of last the year the imports were

Madder, ...	6,846 cwts.
Garancine, ...	533 "

During the first two months of this year they were

Madder, ...	2,185 cwts.
Garancine, ...	175 "

or about two-thirds less. And not only so, but the price is still declining. Turkey roots may now be bought at 11s. per cwt., whereas before artificial alizarin was introduced they were sold, on an average, at 50s. At the present prices of madder, its cultivation is unremunerative, and will, undoubtedly, be soon a thing of the past. Such has been the success of artificial alizarin in competing with madder and garancine in this country, and it is equally true of other countries. The quantity of madder grown in all the madder-growing countries of the world prior to 1868 is estimated at about 70,000 tons per annum. The amount of artificial alizarin now produced is equal in dyeing power to considerably more than this; in fact, the lowest estimate I

have been able to get for 1878, and which was confirmed from other sources, is 9,500 tons, which is equivalent to 950,000 tons of madder. This remarkable result has been arrived at in ten years only.

To produce this quantity of artificial alizarin, there are about nine manufacturers on the Continent and one in this country, Messrs. Burt, Bolton & Haywood, who have two large works for its production, viz., the original works at Greenford Green, and new ones at Silvertown.

Graebe and Liebermann, in their paper in the *Moniteur Scientifique*, April, 1879, p 416, give some statistics of the production of artificial alizarin which, however, require correcting. They also leave out the years 1869 and 1870. In 1869 we had advanced in the manufacture so fas as to send color into the market, the first invoice being dated October 4th, and that year we produced about one ton. In 1870 we produced 40 tons; in 1871, 220 tons; in 1872, 300 tons, and in 1873 435 tons. Up to the end of 1870 we were practically the only makers of this product. One of the largest chemical and coal tar color manufacturing firms of Germany, with whom we were in correspondence, stating that in November, 1870, they had only lately commenced producing 50 lbs. of alizarin, 10 per cent. quality, per day, and that no one else in that country was supplying artificial alizarin, and in 1871 we were practically the only producers of quantity, at any rate during the first part of the year, for in March, 1871, the firm already referred to, and who had great opportunities of knowing what was being done in their country, wrote that they had not received knowledge of any establishment but their own manufacturing artificial alizarin.

In November, 1871, however, Messrs. Gessert Frères announced to the Industrial Society of Mulhouse that they had produced 30,792 kilogrammes of alizarin in paste. This is equal to about 30 tons, an amount which was evidently considered by them a very large quantity.

Graebe and Liebermann's statistics are as follows compared with our production:

	Graebe and Liebermann. Tons.	Perkin & Sons' Production. Tons.
1869,		1
1870,		40
1871,	125-150	220
1872,	400-500	300
1873,	900-1,000	435

Without wishing to detract from Graebe and Liebermann's original discovery, we may say that the birthplace of the manufacture of artificial alizarin was in England. It was in this country that the difficulties and doubts about the manufacture and supply of the raw material, anthracene, were solved, and the production of artificial alizarin by new processes successfully accomplished. After these results were obtained in in this country, Continental chemists were encouraged to manufacture on a comparatively large scale, but up to the end of 1873 the English manufacturers had practically no competition in the home market. Having considered the amount of artificial alizarin now manufactured, it will be of interest to see what its money value is.

Taking the lowest estimate, viz., 9,500 tons, and calculating its selling prices at £150 per ton, the annual value amounts to no less than £1,425,000, or nearly a million and a half.

As a dye, it is now at most not more than one-third of the average price of madder in 1859—1868. Consequently, in the United Kingdom, when the annual value of madder imported was £1,000,000, the annual saving is very great.

While collecting the statistics about alizarin, I thought it would be of interest to get, if possible, the statistics of the entire coal tar color industry, and to the kindness of H. Caro, of the Badische aniline and soda fabrik, I am indebted for most of the following particulars:

Estimated Value of the Production of Coal Tar Colors in 1878.

Germany,	£2,000,000, of which four-fifths are exported.
England,	450,000
France,	350,000
Switzerland,	350,000
Total,	£3,150,000

There are now in this country six coal tar color works; in Germany no less than 17; in France about 5, and in Switzerland 4. There are also three works in Germany and three in France which manufactare aniline in enormous quantities for the production of coal tar colors.

Such is the wonderful growth of this industry, which dates only from 1856. It is the fruit of scientific researches in organic chemistry, conducted, mostly, from a scientific point of view; and, while this industry has made such great progress, it has, in its turn, acted as a handmaid to chemical science, by placing at the disposal of chemists

products which otherwise could not have been obtained, and thus an amount of research has been conducted through it so extensive that it is difficult to realize, and this may, before long, produce practical fruit to an extent we have no conception of. One very important coloring matter related to coal tar, and one of the original sources of aniline—a product of as great importance as alizarin—has yet to be produced on the large scale. I refer to indigo. Baeyer has shown that it can be produced artificially, but at present no practical means of accomplishing it have been discovered. No doubt, however, it will not be many years before this is achieved, and the cultivation of the indigo plant share the fate of madder.—*Journal of Applied Science.*

ROAD MAKING.

By M. JULES LAFFINEUR.

Translated and abridged from the *Annales du Génie Civil* by PLINY E. CHASE, LL.D.

A ballasted road, in good condition, should present a smooth, hard and compact surface, and should form an impermeable covering for the soil upon which it rests; consequently the two qualities to be considered in the materials which compose it are hardness and facility of uniting. Although the union of these two qualities is very valuable, it is far from being always indispensable.

The hardness of the materials presents a very great advantage only for the composition of the upper layer, which is designed to support the direct action of the wheels. As to the lower layer, which, in a good system, ought never to be reached by the wheels of the carriages, it is sufficient that it should be formed of yielding materials, in order to be able to intercept the communication with the soil and to shelter it from atmospheric influences.

As to the size of the ballasting, experience has shown that the most suitable dimension is that of six centimetres (2·36 inches) diameter. It is not necessary that all the pieces should have a uniform size; even if this were possible it would be far from being advantageous. The upper limit should be six centimetres, and there should be fragments of various other dimensions, so that the smallest can lodge in the spaces between the largest, and thus form a mass more compact and

less movable. If the ballasting is very hard, the diameter of six centimetres may be somewhat too great, even for the largest pieces.

When a road has been built after this system, it is far from being immediately fit for traveling, on account of the great amount of draught which it requires. The materials being simply laid against one another, the wheels easily separate them and rapidly produce ruts in which they can move only with extreme difficulty. The travel does not become easy until the prolonged passage of carriages, aided by atmospheric influences, has consolidated the materials, so as to form a compact and resisting mass.

When this consolidation is effected solely by the traffic, it is accomplished slowly, in an irregular manner, and with great loss of force, provided the force is left to act by chance and without any determinate direction. Therefore, roads should not be opened to the public until they are ready for immediate use and they present the least possible resistance to draught. The simplest means of artificially arriving at this result is to use a very large and heavy compressing roller. The roller, however, can never effect so complete a union as is established by long travel. There is probably a chemical action for which time is an indispensable requisite, and for which there is no possible substitute.

When a road has been constructed in accordance with these principles and processes, it should present the maximum of solidity with the minimum of thickness and, consequently, with the minimum of cost. If this thickness appears small in comparison with the one which is generally adopted, it is compensated by the compact and unalterable mass which it forms. In a causeway, for example, with the thickness of 15 centimetres (5·9 inches), if trenches are cut after the road has been for a long time in use, this normal thickness of 15 centimetres will be found everywhere, forming a perfectly compact whole. On the contrary, in a causeway with a thickness of 25 centimetres (9·843 inches), built with materials which are freed from all foreign substances, and consolidated by the travel and by successive additions of ballasting, instead of finding the uniform thickness of 25 centimetres, there will be sometimes 30, sometimes 15, and sometimes only 5 centimetres. Moreover, there will always be a mixture, more or less considerable and often enormous, of detritus, having no union with the larger ballasting; so that such a road, after having used much more ballasting than the former, and having imposed upon the travel a burden ten times as great, will present much less solidity. In the true system there is

not a stone lost, everything concurs to a useful end, and we obtain the best result with the greatest economy of means.

The defects of the common system are manifested to every observer by the great number of permanent and temporary road laborers that are employed. The methods of maintenance which constantly secure solid road-beds reduce the waste to the simple wear of friction and consequently to a minimum. They are the methods which require the least repair and the least expense. In order to maintain a road in perfect order, it is necessary to stop the slightest dilapidations at the outset, and even to prevent their development. The most rational method requires three principal operations:

1. To facilitate the rapid escape of rain-water or of other things which ought never to remain upon the road.

2. The removal of the detritus produced by the wear of traffic as speedily as possible.

3. The prompt application of the materials which are required for repairs.

If the roads have the form which has been indicated, the discharge of the water will be accomplished naturally and easily, without the aid of manual labor, or with occasional slight and inexpensive assistance.

The removal of the detritus may be accomplished at intervals more or less frequent, either in the form of mud or of dust, with different instruments, the principal of which are the rake and the broom. The waste should never be allowed to remain too long upon the road. Mud is always injurious; it maintains a moisture which softens the road and disturbs the whole organization. It hastens the formation of ruts and increases the draught of carriages. Dust is hardly less injurious; it increases the draught, and at the first rain forms mud with all its inconveniences. The removal of the waste should be uninterrupted, and since, in such case, there can never be any great accumulations, the rake and broom will be sufficient.

Roads which are carefully watched, maintaining a sound surface, with very slight depressions, the ballasting requires especial care. The stones should be broken finer than those which are designed for new roads, and only enough should be employed to restore the normal thickness and replace the wear. It should be used only in moist weather, when the road-bed is a little softened. In order to facilitate the adhesion of the ballasting to the old road-bed it is well to indent

the borders and even the whole surface of the new ballasting and to cover it with some of the waste, unless there is considerable quarry gangue. These precautions would always maintain smooth and hard surfaces, nearly free from mud in winter and from dust in summer. They would lead to great savings in the supply of ballasting and in the employment of laborers. The work of the regular laborers should be limited to the simple care of the road-bed. All other work, such as the maintenance of ditches, slopes, sidings, etc., should be done by contract or given out in jobs to special laborers.

CHEMICAL COMPOSITION OF MINERAL COAL.

Abridged from *Comptes Rendus* by PLINY EARLE CHASE, LL.D.

For nearly thirty years Prof. E. Fremy has been studying vegetable tissues, with especial reference to the chemical nature of the principles which they contain, and the influences which have changed them into lignite, bituminous coal and anthracite. He began with examining the vegetable skeletons. The substances which he first studied were almost wholly unknown; their characteristic property is their production, under the influence of a ferment or of reagents, of gums and gelatines. He showed that they are all derived from a primitive insoluble compound, which he called *pectose*, represented in its greatest simplicity by the formula $C_8H_5O_7$, and which, by successive polymeric transformations, forms at first gummy substances, then gelatinous bodies, and finally an acid soluble in water.

He then began the study of the stable elements which form the fibres, cells and vessels. He found that the vegetable frame-work is not so simple as he thought; it is not built up of simple cellulose, differently incrusted by other substances, but of many kinds of isomeric cellulose. There is also, in nearly all parts of the skeleton, a very important body, which differs from the celluloses in composition and properties, which abounds in the vessels, and which he therefore calls *vasculose*. The proportions in which it exists in different kinds of wood, affect their physical qualities. Oak may contain 30 per cent.; in walnut shells there is sometimes 50 per cent. It binds the woody fibres together. Caustic alkalies dissolve it, and they are therefore employed in the manufacture of wood paper.

After ascertaining the composition of the internal tissues, he analyzed the cuticle and other coverings, discovering *cutose*, which is well fitted, by its resistance to chemical change, for protecting the parts which are exposed to the air.

Passing, next, to the bodies which are most often found in the tissues, he showed that gum is a true salt of lime, and that chlorophyll owes its green color to a salt of potash.

In extending his studies to combustible fossils, he first sought what chemical differences characterized wood, peat, the different lignites, bituminous coal and anthracite. He found that wood is not sensibly attacked by a dilute solution of potash, while peat often yields to that alkali considerable quantities of ulmic acid; xyloid lignite, or fossil wood, still contains notable proportions of ulmic acid, but it is easily distinguished from wood and peat, because it is changed into yellow resin by nitric acid and it is completely soluble in hypochlorites; compact, or perfect lignite contains no appreciable ulmic acid, and still it is dissolved in nitric acid and the hypochlorites; as to the true coals, they are characterized by their insolubility in neutral solvents, acids, alkalies and hypochlorites.

In his synthesis, he was guided by the experiments of Daubrée and Baroullier, which indicated the importance of heat and pressure in coal metamorphosis. He performed a series of experiments, in which vegetable tissues and the substances which most often accompany them in organization, were separately kept, for a considerable time, at temperatures from 200° to 300° (392° to 572°F.), in hermetically sealed glass tubes. He found that cellulose, vasculose and cutose all became black, brittle, yielding water, acids, gas and tar, but preserving their organization; they did not melt, but gave a fixed product which showed no resemblance to mineral coal. With sugar, starch, gum, chlorophyll and the fatty and resinous bodies which accompany it in the leaves, the results were very different. By long calcination under pressure they became black, shining, often melted, absolutely insoluble in the tested chemicals, and very different from charcoal, for when heated to redness they behaved like organic bodies, yielding water, etc., but having, as a fixed residuum, a hard and brilliant coke. The chemical resemblance to a specimen of Blanzy coal, which was analyzed by Regnault, is thus shown:

	Carbon.	Hydrogen.	Oxygen.	Ashes.
Coal from sugar,	66·84	4·73	28·43	
" " starch,	68·48	4·68	26·84	
" " gum arabic,	78·78	5·00	16·22	
Blanzy coal,	76·48	5·23	16·01	2·28

He was induced to experiment on these three substances because, according to Ad. Brongniart, they must have abounded in the vegetables which produced the coal beds, and because gum often comes from the transformation of tissues, as Trécul has shown.

Further experiments led him to the dominant hypothesis that vegetables are first changed into peat, and that, in that form, the disappearance of the organized tissues is due to a kind of turfy formation, as Van Tieghem suggested. He then operated on three kinds of ulmic acid: 1, acid which he had himself extracted from peat; 2, saccharumic acid, which he obtained from M. P. Thenard; 3, ulmic acid extracted by treating vasculose by alkalies. They were all transformed into substances similar to the foregoing, under the combined influence of heat and pressure, as is shown by the following analysis:

	Carbon.	Hydrogen.	Oxygen.
Coal from peat acid, heated 24 h.,	67·48	5·84	26·68
Same, heated 72 hours,	71·72	5·03.	23·25
" " 120 "	76·06	4·99	18·95
Coal from vasculose acid,	76·43	5·31	18·26

Finally, he examined the modifications, under heat and pressure, of mixtures of chlorophyll with the fatty and resinous bodies which alcohol extracts from leaves. Although the mixture was at first soluble in alkalies, after 150 hours' treatment it gave a black substance, viscous, insoluble in caustic alkalies, and presenting an evident analogy to natural bitumens.

Alizarin-Carmine.—A new coloring material is manufactured, under this name, by the Austrian Alizarin Manufacturing Company. With tin as a mordant, it dyes wool orange; with alum, red. It is said to surpass all previous dyes of similar tints, in beauty, brilliancy, durability and variety of shading with different mordants, and resistance to change under exposure to light, air, perspiration and washing. —*Fortschr. der Zeit.* C.

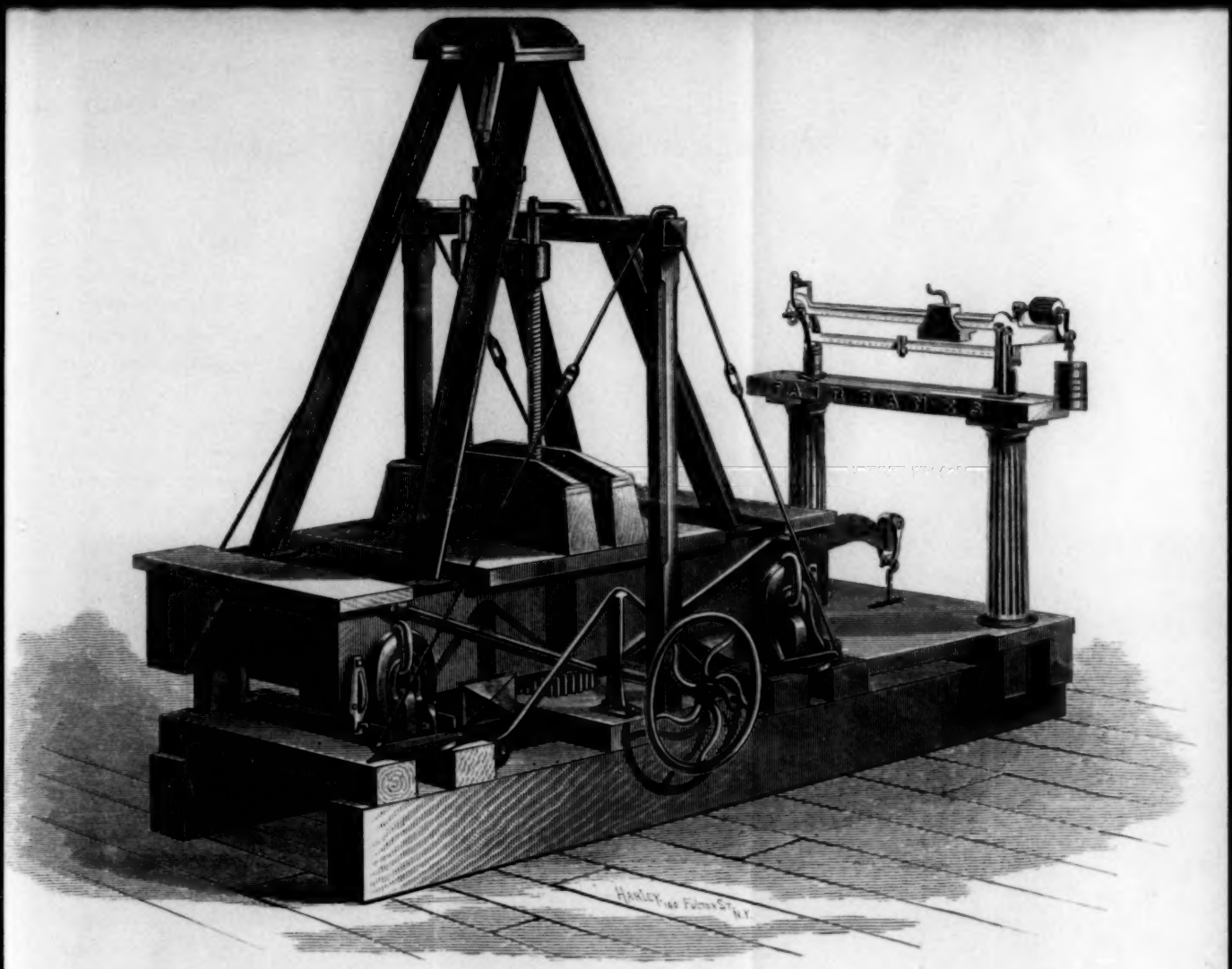
REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS ON THE FAIRBANKS TESTING MACHINE.

HALL OF THE FRANKLIN INSTITUTE,
Philadelphia, March 24th, 1879.

The Sub-committee of the Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, to whom was referred, for examination, Fairbanks' Testing Machine, report that the machine consists of a section of track scale of their usual type, having a platform about 8 feet long by 4 feet wide, resting at its four corners on knife-edges in four multiplying levers. The fulcrums of these levers are supported on knife-edges in links freely suspended in yoke-castings, which are connected together in pairs by transverse wrought iron frames and bolted on a strong, well-braced timber foundation, while the long ends of the levers are connected by means of links and knife-edges with a series of long multiplying levers leading to a graduated beam similar to that of the ordinary platform scale.

This weighing apparatus is excellent, every part being carefully proportioned to the work it has to do, and the whole arrangement being well adapted to insure the greatest accuracy with the least liability to wear or derangement, the only objection to it being the space occupied—12 feet by 6 feet—occasioned by the length of the levers and the openness and simplicity of the construction.

On top of the platform are four inclined cast iron columns supporting a cross-head from which is suspended the wrought iron head with the wedge-shaped clamps for holding one end of the specimen to be tested for tensile strength. The other end of the specimen is clamped in a similar head connected to a cross-head which can be moved up and down by two screws which are supported at their upper ends in bearings bolted to a timber frame-work, and pass down through the platform of the scale to bearings in a strong cross girt between the beams on which the scale rests. The screws are rotated by means of tangent wheels operated by worms on a transverse shaft on one end of which is a pulley with a crank handle. On the other end of this shaft is a large gear wheel worked by a pinion with a similar pulley and crank handle. When motion is given to either of these pulleys, the rotation of the screws draws down the movable cross-head with the clamp holding one end of the specimen, and as the clamp holding the other end is supported by the scale platform, any strain put upon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the specimen will be shown by the beam precisely as if the platform was acted upon by a weight.

When tests for transverse strength are to be made, the specimen is supported on two knife-edges resting on the platform at a definite distance apart, while a central knife-edge on the under side of the movable cross-head is brought to bear upon it by the screws as before.

In testing metals it is essential that the gripe of the wedge clamps on the sides of the specimen shall be uniform and not tighter on one edge than on the other, in order that the strain shall be equal on the entire cross-section and produce no tearing tendency. To effect this, one of the wedges is made rounding on its back and with side play in its seat, so that it can adjust itself to any inequalities or want of parallelism in the specimen.

An ingenious and efficient device is applied to the graduated beam by which the small poise is moved out automatically as long as the beam is up, but stops whenever the beam falls, thus recording the exact point at which the specimen breaks, and enabling one man to make a test with accuracy.

The process of making a test is as follows: After fixing the specimen in place, the heavy poise is set at the notch on the beam at which the specimen is expected to stretch, and the small poise drawn back to zero. The crank on the worm shaft is then rotated until the beam rises, when the small poise commences to move out automatically. At this point it is usual to change to the other crank in order to gain power and to prevent overrunning the motion of the small poise. With care the beam can be kept in a horizontal position with the poise just balancing the strain. When the elastic limit is exceeded, the specimen yields rapidly, the motion of the crank has to be increased, and finally when the specimen breaks, the beam falls, stopping instantly the motion of the poise. The position of the poise then indicates the exact weight which broke the specimen.

We consider this machine accurate and reliable, easy to be understood and manipulated, and with little tendency to wear or to derangement of its parts, and that its design and mode of construction would enable any repairs or renewals to be easily and cheaply made.

WM. H. THORNE.
WM. D. MARKS.
J. HAUG.
L. R. FAUGHT.
JOSEPH ZENTMAYER.

Adopted May 7, 1879.

H. CARTWRIGHT, *Chairman pro tem.*

THE SUN'S COMPOSITION.

At the recent meeting of the Royal Astronomical Society in London, Professor Henry Draper, the distinguished American physicist, brought before an audience of English astronomers and physicists the evidence by which he appears to have demonstrated that oxygen exists in the sun. It will be remembered that when, in 1859, Kirchhoff showed how the dark lines of the solar spectrum enable us to analyze the vaporous envelope of the great central luminary of our system, the substances, the presence of which was recognized, belonged, with one exception, to the family of metallic elements. Iron, zinc, copper, aluminium, sodium, magnesium, cobalt, nickel, calcium, chromium, titanium and manganese were found to be present in the sun. Besides these metals, hydrogen was recognized. It is doubtful whether even hydrogen ought not to be included among the metallic elements, for the late Professor Graham succeeded in forming what he regarded as an alloy of hydrogen and palladium, which (if his interpretation of the experiment was correct) would oblige us to consider hydrogen as a metal no less than palladium. In that case hydrogen would be regarded as a metal which, at ordinary temperatures, is in the gaseous form, precisely as mercury is, at ordinary temperatures, a fluid metal. Adopting this, which is probably the correct view, we may say that all the elements the presence of which in the sun had been determined by dark lines—that is, by absent, or rather by relatively feeble tints—in the solar spectrum are metallic. The absence of all evidence respecting some of the other elements might not have seemed remarkable, because it might well be believed that they were present in quantities relatively so small that our means of analyzing the sun failed to detect these substances. We could thus understand why spectroscopists should have obtained no evidence of the presence of gold in the sun, the element by the way, which the alchemists and astrologers of old times regarded as specially solar. But that such elements as oxygen, nitrogen and carbon, which are such important constituents of our earth, should be absent from the sun, or should not be present in quantities large enough to make their detection easy, seemed surprising. The wonder was increased in the case of the two latter elements by the circumstance that Dr. Huggins recognized the presence of nitrogen in

the faint mist-like objects, the gaseous nebulæ, and the presence of carbon (though not quite so satisfactorily) in certain comets. But though no spectroscopic evidence of the presence of oxygen in any of the self-luminous celestial bodies had been obtained, so that the absence of any evidence of oxygen in the sun was in one sense less remarkable, it was in another sense the most remarkable of all the negative results of solar spectroscopic analysis. Oxygen is commonly believed to form one-third of the mass of our earth's crust, and is known to form eight-ninths of the water where it is combined (that is, chemically associated) with hydrogen, and one-fifth of the air where it is mixed (not combined) with nitrogen. We cannot, it is true, assume that the structure of the sun is identical with that of the earth; indeed, many consider that each planet, according to its distance from the sun, is differently constituted, having the same elements, perhaps, but in different proportions, while the sun is unlike them all. Yet it would be difficult to understand how in the great central mass, in which the denser elements would be the more abundant, the lightest of all, hydrogen, should be present in enormous quantities, while oxygen, so much denser under the same conditions, should be absent or present only in such small amount as to afford no evidence of its existence. The natural inference would be that oxygen and the other non-metallic elements, though really present in the sun, are situated below that visible surface of the sun which we call the photosphere. That at any rate they are not present above that surface in any considerable quantity is clearly shown by what happens during total eclipses of the sun; for whereas, at the moment when the sun is just fully hidden by the moon, the metallic elements usually recognized by the absorptive action of their vapors on the sun's light can be recognized by their emissive action, a rainbow-tinted array of bright lines suddenly replacing the rainbow-tinted streak crossed by a corresponding array of dark lines, the bright lines of oxygen, nitrogen, carbon and other non-metallic elements have never been recognized, even under these favorable conditions. But if oxygen existed in enormous quantities within the visible globe of the sun, its presence might be recognized in another way. Besides the dark lines in the solar spectrum, there are bright lines certainly at times, and probably always. Some, indeed, have said that as the glowing vapors which produce the rainbow-tinted array of lines just mentioned, are at all times present over the sun's surface, there are always bright lines; but as the question is always of relative brightness, and

as these particular tints are fainter—corresponding, in fact, to the dark lines—this mode of speaking seems as incorrect as it would be to describe the dull disk of a small red hot globe, seen projected on a bright background at a white heat, as forming a bright instead of a dark spot on that bright white background. When, however, as sometimes happens, the known lines of some element disappear and presently reappear as bright lines, we perceive that for the time being the spectroscopic evidence respecting that particular element is changed in character. We know that that element is present in the part of the sun examined, but we know this because we see the bright lines, not, as usual, the dark lines of that element. This happens frequently, for instance, in the case of hydrogen, when those exceedingly bright parts of the sun's surface, which are called faculæ, are examined. For the time being, the hydrogen there, probably to a depth of many thousand miles below the visible surface, is glowing with a heat exceeding that of the matter forming the photosphere, regarded as a whole; thus, the hydrogen indicates its presence by its emissive, not by its absorptive, action. If oxygen were present in very great quantities in the sun, but always lay below the visible solar surface, and was at a higher temperature than that prevailing at the surface, then oxygen might indicate its presence by its bright lines, and could certainly indicate it in no other way. Now it is evidence of precisely this kind that Professor Draper seems to have obtained respecting this most important element. He had been engaged since 1863 in obtaining simultaneous photographs of parts of the solar spectrum and of corresponding parts of the spectra of hydrogen, nitrogen and carbon. In examining a series of such photographs, in which the fluted spectrum of nitrogen was in juxtaposition with the solar spectrum, he found reason to suspect that some of the bright lines of nitrogen agreed exactly in position with bright bands in the spectrum of the sun. Pursuing his researches, he found, even at that early stage of his labors, very striking evidence of agreement between the bright lines of oxygen and solar bright bands. It was not, however, till the year 1877 that he was so far satisfied as to announce "The Discovery of Oxygen in the Sun." The paper thus named was illustrated by enlarged views of the negatives he had obtained. So that, in point of fact, the reader was provided with the very evidence which had satisfied Professor Draper. He did not merely send pictures of what he had seen, but the observations themselves, seeing that the photographs remained pre-

cisely as nature had left them, save only for a few reference lines and letters added around the margin to make them intelligible. In these photographs a part of the spectrum of the sun was seen side by side with the bright-line spectrum of air. The bright lines of iron were shown in company with those of air, in order to indicate the exact agreement of the juxtaposed spectra by the coincidence of the iron bright lines with the corresponding solar dark lines. Every one of the oxygen bright lines was seen to coincide with a bright part of the solar spectrum. In some cases the coincidence was very striking, because the bright line of the air spectrum not only agreed exactly in position, but very closely in character also, with a bright band in the solar spectrum. This close resemblance could not in every case be recognized—a circumstance by no means surprising when we remember that if these bright bands in the solar spectrum are really due to the presence of great quantities of oxygen below the visible solar surface, the light of this oxygen can only reach us after passing through the cooler envelope of metallic vapors which produces the dark lines, and must be affected by the absorptive action of those vapors, which, of course, was not the case with the oxygen of the air from which Professor Draper obtained the bright-line comparison spectrum.

Many experienced spectroscopists remained unconvinced by the evidence which Professor Draper thus advanced in 1877. They considered that the dispersive power of his spectroscopic battery was not sufficient to place beyond question the coincidences on which he based his conclusions. Other objections also were advanced which need not here be dwelt upon. In the true scientific spirit Professor Draper set to work to apply more searching tests to his result. The scale of his enlarged photograph had been half that of Angstrom's well-known "normal spectrum." Those which he exhibited last Friday at the Astronomical Society were on a scale four times greater. The evidence derived from each coincidence was thus increased four fold in value, the evidences from two coincidences sixteenfold; from three, sixty-four fold, and from the eighteen recognized coincidences about 68,725,000,000 times. He effected also an improvement likely to have great value in other spectroscopic researches. The electric spark through air, which gave the air spectrum, pursued a zigzag course, like a lightning flash on a small scale. He wanted a straight flash, or at any rate a flat flash, as that seen from one direction it should appear as a straight line. So he invented what he calls the spark-compressor. The terminals

between which the spark passes are introduced into a small block of soapstone, and between them a small flat aperture is prepared, between the walls of which the electric flash has to travel. This space is left open on one side, somewhat like the slit of a money-box, and the spark seen from that side necessarily appears as a straight line, though it may have a considerable amount of zigzag play in the plane of the flat space left for its passage. The result of this arrangement is that the spectrum of the air lines—oxygen and nitrogen—as also of the iron lines, obtained by having a little iron at one of the poles, is much better defined and more trustworthy than it had been before this plan was adopted.

It may be interesting to say, in conclusion, a few words about the labor and time involved in this research. The bobbin of the Gramme machine revolves once for each spark used in obtaining the photographs of the air spectrum. Each photograph requires 30,000 sparks, and the photographs obtained in the last three years have required no less than 20,000,000 sparks; so that the bobbin of the Gramme machine has revolved 20,000,000 times. Although the petroleum engine used for driving the machine consumes only a couple of drops of oil at each stroke, 150 gallons have been used up in three years.

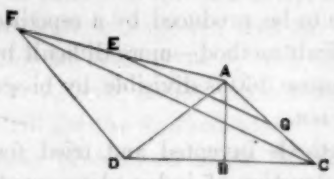
Formation of Hail.—M. G. Oltramare points out two different results which may arise when air that is saturated with moisture becomes chilled. The watery particles may collect in drops and fall by their own weight, leaving the air transparent; or they may remain in suspension and form a cloud. In the latter case he supposes that the molecules are kept apart by electrical repulsion. Jamin and other investigators have found that the watery particles in mists, may remain liquid at —14°, or even at —20° (6·8° or —4° Fahr.), provided there is no sudden shock or solid contact, especially with ice. In such a conditon of "superfusion," if there is a sudden discharge of electricity the separating force disappears, and the sudden union of particles, under their joint attractions, forms hail-stones of various magnitudes. This explanation accounts for the rustling which is heard before a fall of hail, as well as for the accompanying electrical phenomena. The size of the stones depends partly on the thickness of the cloud, partly on the lowering of temperature in superfusion.—*Comptes Rendus.* C.

APPROXIMATE QUADRATURES OF THE CIRCLE.—II.

By Pliny Earle Chase, LL.D.

Since the publication of my graphic approximation in the July number of the Journal of the Franklin Institute,* my attention has been called to the following construction in Perkins's Geometry (D. Appleton & Co., 1853).

On an indefinite straight line AN, lay off $AB = BD = DE = 1$; at E erect a perpendicular $EG = 2AB = 2EF$; on EN lay off $EH = HK = AG$, KL (towards A) $= AF$, LM (towards N) $= DG$, $MN = DF$; bisect EN at P, EP at R, and AB at C; trisect ER at T. Then $CT = 3{\cdot}1415922\ldots$



The author calls his method "very simple," and says that a better one "can hardly be expected, or even desired." But the approximation of Adrian Metius, $\frac{355}{113}$, is still closer, and the following construction of his ratio is more simple:

On $AB = 7$ erect the perpendicular $BC = 8$; extend CB to D, taking $DB = 9$; on AD erect the perpendicular $DF = 15$; take $AE = AC$ and draw EG parallel to FC. Then $AF = \frac{355}{113} AG = 3{\cdot}14159292\ldots AG$, the true ratio of the circumference of the diameter being 3.14159265. . . . The error of this construction is less than $\frac{1}{116000}$ of one per cent. Perkins's error is a little more than $\frac{1}{70000}$ of one per cent. Neither method is so simple nor so desirable for practical purposes as the one which was given in the last number of the Journal.

Haverford College,
July 16th, 1879.

* p. 45. In the last line of the third paragraph, *for* $23AC'$ *read* $= 3AC'$.

A NEW METHOD OF CONSTRUCTING INDEX PLATES FOR GEAR CUTTERS.

By Prof. John E. Sweet.

The making of practically perfect index plates for gear cutting machines is a different matter from graduating circles for astronomical instruments.

Imperfect as graduated circles prove to be, when subjected to the test of astronomical observations, or triangulating, as practiced by the Coast Survey, they are no doubt quite accurate enough for the index of a gear cutter; yet transferring the graduations from the circle to the index plate introduces sources of error, and besides, the graduations will serve for making but one of a hundred rows of holes, and thus, ninety-nine other rows would have to be produced by a repetition of the same tedious and even more difficult method—more difficult by the method of sub-division, at least, because 360 is divisible by bi-section to a low degree, while 97 or 89 are not.

An account of the different methods invented and tried for the division of the circle and the construction of index plates would be interesting; but one attempting to write such a history who had not made it a life study would be likely to omit more of the ways than he remembered to recount. So I describe the following method, which I believe to be new, leaving the history and comparison to the enthusiast or more experienced.

To make one or more plates with 69 circles of holes, increasing by 4 from 228 to 500, in a plate about 5 feet 6 inches in diameter, the following method is suggested:

500 hardened steel bushes, $\frac{4}{10}$ inch in diameter, about $\frac{1}{2}$ inch long, with holes perhaps $\frac{1}{10}$ inch in diameter through their centres, are to be used. The holes are to be ground perfectly true to size, on the system of the Whitworth cylindrical gauges, and their outer surfaces ground to perfect cylinders, uniform in size and concentric with the holes. Such work is now done by the "American Standard Gauge and Tool Company," and guaranteed to $\frac{1}{25000}$ inch.

The steel bushes, which serve the double purpose of dividing the circles and guiding the drill in drilling the plates, are to be used in the

following manner: A cast iron disc or template, $\frac{1}{2}$ inch thick, somewhat larger than the plate to be made, has on its lower side three projections, bored so as to embrace the outer edge of the plate, and locate the two, concentric with each other. The two being mounted in the lathe, a hole is bored in the template so as to embrace, by a close fit, 228 of the steel bushes when placed within its inner surface, the template to be warmed when the bushes are inserted, and allowed to shrink upon them.

Through these bushes the inner circle of holes is drilled, the bushes removed, and the template bored to contain 232 other bushes, through which the second circle of holes is drilled, and in like manner the other 67 circles.

By using the bushes successively, no bush would be used more than 51 times nor less than 50.

By this method the sources of error are reduced to a minimum. Just so perfect as the bushes can be ground, just about that perfect it might well be expected that the plate would be drilled. Probably drilling the holes $\frac{1}{12}$ or $\frac{1}{14}$ inch, and then enlarging them by a counterbore to $\frac{1}{10}$ inch, would insure a more perfect result than by trusting to the drill for the finished hole.

Other precautions might be taken, such as drilling *up*, that is, with the face down; and some arrangement for heating the template with warm water before setting the bushes would be likely to insure more perfect results.

The cost of this method would be excessive, but if five or ten plates were made at the same time, the cost would be proportionately less.

Cornell University, Ithaca, N. Y.,
June 16th, 1879.

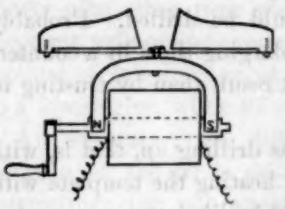
Glaciers in the Maritime Alps.—The existence of moraines on the Ligurian coast has often been questioned, and geologists have been unable to point to any conclusive evidence of a former icy sea, analagous to the one which had so many outlets in Piedmont. M. C. Desor after vainly exploring the neighborhood of Nice, has found well-marked moraines about 20 kilometres (12·43 miles) in the interior, at the foot of the jurassic masses which form the outposts of the mountains.—*Les Mondes.* C.

A NEW GENUS IN TELEPHONES.

By Prof. A. E. Dolbear.

The common form of speaking telephones relies for its action upon currents of electricity developed in helices by the varying strength of magnetic induction when an armature moves in the magnetic field. These currents, traversing other coils about the poles of a magnet, vary the inductive strength of it and thus set its armature in motion as the first is moved. There are many forms of these instruments, all known by the generic title of magneto-telephones.

Edison has developed out of his motograph, which was invented several years ago, a receiving telephone, which is said by those who have heard it to be surprisingly loud. Its principle of action is entirely distinct from that of the magneto-telephone, and depends solely upon the varying friction between two surfaces, one of which is an electrolyte, when a varying current is passed between them. The stronger the current the less the friction, and these conditions are so rendered mechanically as to effect a transformation of electrical waves into corresponding sound waves in air. This is a distinct genus with but one species to represent it.



The following is a description of still a third kind, as unlike either of the former as they are unlike each other. While experimenting with a common string telephone with a screw tied to the end of the short string of three or four inches, the screw being made the armature to an electro-magnet in circuit with an Edison transmitter, I found that the speech was rendered plainly when the screw adhered to the pole of the magnet, provided that the screw was slowly dragged over it while the variable current was passing. The interpretation of this phenomenon was instantly perceived and I have had constructed an instrument in which these conditions are employed to greater advantage. A short straight bar electro-magnet is furnished with a crank, as in the diagram, so it may be rotated within its coil. Lying upon the poles of this magnet are the ends of a bent armature, marked

N and *S*. The back of this armature is fastened to a plate of mica or paper, or thin iron, mounted as such plates are in ordinary receivers, so that any motion of the poles *N* and *S* will be imparted to the plate. Suppose a current of electricity traverses the bobbin, the straight bar becomes a magnet with strength proportionate to the strength of the current, and the armature will adhere to the poles of it with a certain degree of adhesion. Now let the crank be turned slowly, and the adhesion of the armature will result in stretching the plate and the cessation of the current will permit the plate to regain its former position through its own elasticity. A varying current will result in varying adhesions and the consequent vibrations of the plate, and talking may plainly be heard with an instrument constructed thus. This instrument I have named the Rataphone. Of course there are many ways in which this principle may be utilized. Instead of rotating the magnet the ends of the armature may be prolonged, and rest upon a cylinder or pulley, which may be rotated, and the varying attractions will cause the diaphragm to vibrate. If a strip of paper be put between the armature and the poles of a common relay or sounder, which is in circuit with a transmitter, and the paper be slowly drawn along while an intermittent or vibrating current passes, the ear applied to the paper will hear the sounds, and articulate speech, if the current be varied by such sounds, and if the armature itself be so made as to rotate, the same effects will be produced.

TUFT'S COLLEGE, *College Hill, Mass.*

Galvanic Dilatation.—In order to test Edwards' hypothesis that the passage of a galvanic current produces a mechanical elongation, M. Blondlot has contrived a delicate experiment. He takes a strip of copper, thoroughly annealed, which he bends into a kind of quadrangular spiral, fastened at its upper end and carrying at its lower extremity a shaft which plunges into mercury. When a current is passed through the spiral, all the angles should vary if there is any dilatation, and as all the variations are cumulative the terminal stalk should turn through an angle which could be easily measured by Poggendorff's method. An elongation of ·00000025 could be readily detected in this way, but as he found none, Blondlot concludes that the hypothesis is is incorrect.—*La Nature.* C.

RESEARCHES WITH PROF. HUGHES' AUDIOMETER.

Paper read before the Royal Society May 15, 1879,

By BENJAMIN WARD RICHARDSON, M.D., LL.D., F.R.S.

Professor Hughes having done me the honor to show me first his newly invented instrument for the measurement of hearing, and having supplied me with an instrument for the purpose of testing the application of it for physiological and practical purposes, I have been enabled to make a considerable number of experiments, on which I venture to submit the following preliminary report:

The instrument, as it has been used, is before the Society. It consists of two Leclanché's cells for the battery, a new and simple microphonic key connected with the cells and with two fixed primary coils, and a secondary or induction coil, the terminals of which are attached to a telephone. The induction coil moves on a bar between the two fixed coils, and the bar is graduated into 200 parts, by which the readings of sound are taken. The graduated scale is divided into 20 centimetres, and each of these parts is subdivided into 10, so that the hearing may be tested from the maximum of 200 units to 0°—zero. The fixed coil on the right hand contains 6 metres of wire; the the fixed coil on the left hand contains 100 metres. By this means a long scale from the left hand coil is produced. The secondary coil contains 100 metres of wire.

In using the instrument, one Leclanché's cell has been found sufficient, as a general rule, but two have been used in instances where the hearing of the person under test has been very defective. The Leclanché cell was selected by Professor Hughes as affording a reliable current for the purposes he had in view, and for standard comparisons. In using the instrument, the induction coil is moved along the scale from or towards the larger primary, as may be required, and the degrees or units of sound are read from the figures on the scale, the sound being made by the movement of the microphonic key between the battery and the primary coils.

The person whose hearing is being tested should sit in an easy position, and should not see the act of the observer in moving the microphone key. For good observation, the room in which the experiment

is made should be large, and all external causes of sound, such as the ticking of clocks, the vibrations of windows and doors, the moving of feet and the singing from gas jets, should be silenced. The sitter should close the ear that is not applied to the telephone while he is listening for minute sounds, and should give his full and calm attention to the proceeding. Any excitement is likely to lead to error when refined measurements are required.

The instrument may be considered to afford the most satisfactory means for testing the hearing power of all persons who can define a a sound. The range of sound is sufficient at the maximum—200°—for everyone who is not absolutely deaf, 0°, or zero, is a point of positive silence from the instrument, or rather from the sound which it produces through the telephone.

One of the first facts learned with the audiometer is the suddeness with which the sound is lost to those who are listening. The sound is abruptly lost within a range of 2°; that is within one-hundredth part of the entire scale. This is the case with those who are very deaf, as well as with those who hear readily, a fact originally noticed by Mr. Hughes, and which I have corroborated by fifty special observations on different persons presenting powers of hearing which varied from 200° to 140° as the extreme limit or capacity, to complete hearing through the whole scale down to zero. In these persons, when the observation was taken, under the strictest possible conditions for surrounding silence, the point between distinctness of sound and complete loss of it was not more than one-hundredth part of the scale.

In testing the capacity of hearing, it is noticeable that the power to detect the diminishing sound is maintained best by continuing the reduction in trace or line while the attention is fixed. A sudden break may cause the sound to be lost to the listener long before his real incapacity to hear is reached. If, for instance, the sound be very faintly heard at 15°, and the induction coil be suddenly moved to 5°, the sound at 5° may be quite inaudible; but if the coil be slowly moved, unit by unit, from 15° to 5°, the sound at 5° may be distinctly heard. Mr. Maitland Tate, C.E., who noticed this point very markedly in his own case, when I was submitting him to test, compared this to what is observed by the sense of sight in making surveys. The eye will follow a line to an extreme point with comparative readiness, but if it break away from it, the object seems to have disappeared.

The effect of filling the chest and holding the breath makes a differ-

ence in listeners. The capacity for hearing is for a few seconds increased by holding the breath. Mr. Tate, who could hear with his right ear only down to 8° under ordinary breathing, could hear down to 5° when he held his breath. Another gentleman, who could hear only down to 100° under ordinary breathing, could hear to 80° when the breath was held with the chest full. Holding the breath with the chest not full fails to produce the same result.

As a rule, the hearing of persons who are right handed is most refined in the right ear, and as most persons are right handed, it is found that the right ear is the best ear. This rule is, however, attended with many exceptions, since, for various reasons, some persons who use the right hand exclusively, practise for some particular purpose the use of the left ear, upon which that ear becomes more acute. Thus five physicians, who were right-handed but who had accustomed themselves to use the stethoscope with the left ear, could hear to zero on that side, but had lost from 4° to 5° on the right side. Four other persons who were similarly circumstanced were able at once to account for the fact by the habit they had acquired of listening to a public discourse or sermon from the left side. Another point of interest attaching to this observation is that the practice of using one ear for special refinement of the sense seems for the time slightly to impair the other ear, although there is no physical evidence of such impairment.

Connected with last-named fact is another, namely, that by this instrument the deaf are found to fail in capacity of hearing not only by reason of physical defect, but also by failure of memory of sounds. Thus in a youth who had suffered serious defect of hearing for seven years, owing to partial destruction of the tympanum, and who in the right ear could only detect sound at 107°, there was an inability to catch all the sound lying between 130° and 107° until he could remember what he had to listen for. By practising him then to detect the lowest sound that he was physically capable of receiving, I got him to detect this one sound more readily than those which came higher up. By further practice all the intervening sounds became audible with equal facility. These facts which have been confirmed by another observation on a different person, seem to me to indicate that deafness from imperfection of the tympanum or other parts of the organ of hearing may be increased, beyond the mere physical failure, either from some lost power of automatic adjustment in the auditory apparatus, or from failure of receptive power in the cerebrum itself, so that

the memory rendered imperfect is slow to assist the listener until by exercise of function its readiness is restored.

By the use of audiometer, the influence of atmospheric pressure on hearing is detectable. In my own case when the barometer is at 30°, I can hear on both sides close down to zero, but below 30° I fail by 2° on the left side to reach zero. In another person a similar failure extends to a loss of 4°.

I have tried to determine in some of the lower animals whether there is the same sense of hearing as in man. In most animals it is difficult to obtain sufficient quietude to enable the observer to gather from expression or movement of the animal the information sought for. In two dogs, one a terrier, the other a field spaniel, I succeeded in making some good observations, and in them the range of hearing power seemed to be distinctly lower than it is in the human subject who has perfect hearing. In both these animals, which were healthy and in the prime of life, the first indication of the detection of sound commenced at 10° on the scale. The detection was evidenced by the sudden expression of listening, by a slight change of position, and a slight dilatation of the pupils. This detection was clearly made on the instant, as if the sharp line or hearing were the same in them as it is in the higher animal.

Practical Memoranda.

1. The audiometer will, I think, be an essential in all physical examinations of men who are undergoing examination as to their fitness for special services requiring perfect hearing, such as soldiers, sentries, railway officials, and the like.

2. The instrument will be of great use to the physician in determining the value of hearing in those who are deaf, and in determining the relative value of the two organs of hearing. In one instance, already, I have been able by its means to detect in a person who was supposed to be equally deaf on both sides, that on one side the hearing is perfect close up to zero, while on the other side nine-tenths of the hearing is lost.

3. In other forms of diagnosis I have found the instrument useful. In a young person suffering from acute anæmia the hearing was so defective that on the right side it failed to detect sound at 18°, and on the left side at 15°. In ten days, during which, under a new regimen, great improvement took place in strength and general condition, the

power of hearing had so much improved that the right ear was good down to 12°, and on the left to 3°; an improvement of 6° on the right and of 12° on the left side.

In another person who was subject to repeated vertigo, the giddiness occurring three or four times a day, the hearing was so defective that although the external ear on each side was clear and the tympanum natural, no sound could be heard below 30°. Under complete rest and attention to diet, the vertiginous attacks were in a few days removed altogether, and with that removal there was gain of hearing, on both sides equally, up to 5° on the audiometric scale.

4. The instrument may be used to differentiate between deafness through the external ear and deafness from closure of the Eustachian tube,—throat deafness. In my own case I fail to detect sound by the mouth at 170°, and this I find is a fair average in those who are healthy. It represents the comparative value of communication by sound through the Eustachian canal and the external ear.

5. The instrument promises to be very useful in detecting the effects in the body of those agents which quicken or excite the circulation, such as alcohol and other similar chemical substances. I have some observations on these points in reserve for a further report.

6. The instrument promises to be of great service in determining the value of artificial tympanums in instances of deafness due to imperfection or destruction of the natural tympanum. The cotton artificial tympanums, introduced originally by the late Dr. Yearsley, and the membranous tympanums, introduced by the late Mr. Toynbee, F.R.S., have proved of much service; and by means of the audiometer I have been able very accurately to test their respective merits and to compare both with tympanums made of other material. The inquiry has led me to test different metals for this purpose, and to find in fine gold the substance for making the most useful and effective artificial drum. The Messrs. Ash, of Broad street, have made for me various forms of gold drums, the best of which, perhaps, is a little cylinder which, with other forms, is placed before the Society. With one of these cylinders I was able to give to a young gentleman who had lost hearing on the right side up to 110°, from destruction of the tympanum, an instant gain down to 60°, a gain of 50° on the audiometric scale.

In this preliminary report I have omitted many subjects of interest, but I hope I have related enough to show that the world of science in

general, and the world of medicine in particular, is under a deep debt of gratitude to Professor Hughes for his simple and beautiful instrument, which I have christened the audimeter, or less correctly but more euphoniously, the audiometer.—*The Telegraphic Journal.*

DEPREZ'S ELECTRO-MAGNETIC ENGINE.

By the Count du Moncel.

According to Count du Moncel, writing in *La Lumière Electrique*, M. Marcel Deprez has succeeded in solving the problem of making an electro-magnetic motor capable of doing useful work in many industrial applications. We venture to doubt whether the new motor can compete with even a water-motor as regards economy, to say nothing of gas and steam engines; but, according to Du Moncel, Deprez's apparatus is barely eight inches long, by less than six inches in breadth; it weighs about 6½ pounds and can supply a power of nearly eight foot-pounds per second with five Bunsen elements. This, says Du Moncel, is really an extraordinary result, and one which could scarcely have been anticipated a few years ago. Under these conditions sewing machines may with perfect ease be worked by electricity without any cumbrous apparatus. This ingenious system consists of a horseshoe magnet of eight plates 5¾ inches in length, between the poles of which is introduced a Siemens armature, acted upon by the magnet over a length of 2¾ inches. Up to the present time no one has ever thought of causing magnets or electro-magnets to act otherwise than by their polar extremeties, and all the engines devised hitherto have been arranged on this principle; but M. Marcel Deprez, thinking that under these conditions the whole of the magnetism that can produce a magnet was not utilized, endeavored to cause the whole of the sufficiently-magnetized portions of the magnet engine to act upon the mobile system to be influenced; that is to say, in the present case, the branches of the magnet nearly up to the neutral line. The electro-magnetic armature, instead of being placed transversely to the magnet, is arranged longitudinally and parallel to it. Under these conditions the magnetic power exerted on the armature is found to be considerably augmented, as is perceptible from the difficulty experienced in producing rotation, and this increase of force may give an idea of the consid-

erable advantages presented by this system of motor, which works by the effect of successive reversals of the current. Everybody knows the Siemens armature; it is a kind of galvanometer frame, of which two sides constitute the two poles of a straight electro-magnet with a flat core, broader than it is long, upon which the wire is wound. The axis of this electro-magnet is parallel to the coils of wire in the magnetizing helix, and consequently to the arms of the magnet. At one end it carries a reversing commutator, and at the other end it is provided with a pinion which gears into a wheel of which the diameter is thirty times greater. When the apparatus is properly regulated, the armature makes ninety revolutions per second, and, consequently, the wheel which it acts upon makes three revolutions. It is upon the axis of this wheel that are fixed the pulleys transmitting the movement, and by which the engine is caused to work either a sewing machine or any other apparatus which is to be set in movement. In order to render the working of the apparatus perfectly uniform, M. Marcel Deprez has adapted to it an extremely ingenious regulator, the action of which is very efficacious. It is a sort of spring fixed by one of its extremities to one of the ends of the armature. By means of a screw, a tension suitable for any given velocity of the engine is given to the spring. The transmission of the current from the commutator to the wire of the armature is effected without difficulty by this spring, as in the case of all frictional contacts; but when the velocity is greater than that which is requisite, centrifugal force is brought into action, and the mass of the spring causes it to fly off and to break the circuit, whence results a slackening of the speed, and then the completion of the circuit, which is again broken when the velocity again becomes too great. These alternations are so rapid when the electric power is somewhat higher than is strictly necessary, that a continuous spark is seen at the commutator where the regulating spring is in contact with it. Nothing can be simpler than this little apparatus, which, as at present constructed, may be of great service. Its force may be estimated by trying to stop the pulley, the diameter of which is nearly four inches. With five Bunsen elements at work, this stoppage can be effected only with great difficulty; whereas with the ordinary electro-magnetic engines it is easy to produce a stoppage by pressing a little upon the axis of rotation. Count du Moncel does not say what is the cost of five Bunsen elements, nor where they are to be placed when employed in working a sewing machine in a lady's boudoir.—*English Mechanic.*

REVERSAL OF MOTION WITHOUT GEARS OR BELTS.

Editor Journal Franklin Institute:

DEAR SIR—I note on page 417 of your issue for June, as a translation from a French journal, a description of an alleged invention of M. Bourdon for "reversing motion without gears or belts." Just how old the method described may be I am not aware; but the first published account of it, within my knowledge, is contained in an illustrated work published at Lyons in 1719, which purports to be a description of the models contained in the cabinet of M. Grolier de Serviere, by his grandson; this would probably place the date of the invention (if original with M. G. Serviere) somewhere about 1650. In the work named it is shown as communicating motion from a horizontal crank shaft to a crank on the axis of a submerged rotary pump. Further, the device claimed as M. Bourdon's invention was used in the second pumping engine erected (in 1857, I think) for the supply of water to the City of Chicago. In this particular case the motion was transmitted from an *eccentric* on the main shaft to a crank on the end of a revolving shaft, on which were the cams for actuating the valves of the engine. The same arrangement was repeated, with slight modification, in a pair of pumping engines built for the same city about ten years subsequently. I think the above-named engines were constructed at the Allaire works, New York.

Verily, such claims as those of M. Bourdon recall the saying of Chaucer: "Oute of olde bookes come all this new knowledge that men lere."

Yours truly,

W. F. DURFEE, C.E.

Bridgeport, Conn.

Photographic Transit Measurements.—M. Cornu has been investigating the best theoretical conditions for measuring the photographs of the transit of Venus, with especial reference to the micrometric determination of angular distances. From Mouchez's photographs he deduces a value, for the sum of the radii of the sun and Venus, which differs from the value in the *Connaissance des Temps* by less than $\frac{1}{4}$ of 1 per cent. This indicates a possibility of determining the sun's distance, by photographic observations, within $\frac{1}{10}$ of 1 per cent., or within less than 100,000 miles.—*Comptes Rendus.* C.

GJERS' IMPROVEMENTS IN MAKING IRON AND STEEL.

Among the processes recently patented in connection with the dephosphorization of iron, that of Mr. Gjers, of Middlesbrough, is sure to attract attention. In the Bessemer process, as at present carried on for the manufacture of steel and ingot iron, the slag which is all formed in the early part of the blow from the oxidation of the silicon and some of the other impurities in the original pig iron is allowed to remain in the converter until the end of the process, and is continually being agitated and mixed up with the purified product. Experience has, according to Mr. Gjers, shown that it is not usually practicable to stop the process, as theoretically should be done, at the point when the desired percentage of carbon still remains in the steel; and the reason is chiefly that the tenacious silicious slag does not separate readily from the steel, but more or less contaminates it, and that when the charge works extra hot some of the silicious slag formed at first is even decomposed by the subsequent carbon flame, and causes some silicon to remain to the end, rendering such steel, if it is attempted to tap off before all the carbon is expelled, unworkable and of bad quality. The consequence is that more or less overblowing is resorted to, which again involves the use of spiegel or ferromanganese for the threefold purpose of deoxidizing the charge, rendering the slag more fluid so as to thoroughly separate it, and restoring the desired quantity of carbon. According to the invention patented by Mr. Gjers, as soon as all the slag has formed, and before or about the time when the carbon flame distinctly appears, the converter is turned down and the whole of the slag removed. The converter is then turned up and the blow continued as usual until the carbon is exhausted. Spiegel may then be added, but the patentee prefers, and is enabled through the absence of contaminating slag, to finish the process before the whole of the carbon is exhausted, and thus is able to produce a good and workable quality without the addition of spiegel. But where it is desirable to have a small quantity of manganese in the steel, he adds the desired quantity in the shape of rich ferromanganese in the solid state. In treating pig iron containing phosphorus he prefers to use a neutral or basic lining chiefly constituted of alumina or lime, which linings are now well known. He then charges with the fluid iron in the converter from 10

to 20 per cent., according to the amount of phosphorus and silicon the pig iron contains, of basic material, a mixture, say of 50 per cent. lime and 30 per cent. of rich oxide of iron (by preference magnetic), and 20 per cent. oxide of manganese, or other proportion of this or other basic material calculated to form a fusible slag with the silica formed by the oxidation of the silicon in the pig iron, and blow as above explained. The whole or the greater part of the phosphorus will be found to have left the iron and gone into the slag. In lieu of removing the slag from the converter by simply turning down and raking it off, it may in practice be found convenient to pour the metal out of the converter into a ladle, keeping the slag back, and then to empty the slag out of the converter and return the clean metal to the converter; or the partially blown metal and the slag may be poured into a ladle having a bottom plug, and the metal returned to the converter through the bottom hole, leaving the slag in the ladle. Mr. Gjers does not claim the use of a basic lining, or the adding of basic material to the charge in the converter, either separately or conjointly, but he claims as his invention removing the slag in the Bessemer process before or about the appearance of the carbon flame, and subsequently completing the blow.—*English Mechanic.*

BEET ROOT SUGAR.

The successful manufacture of beet sugar in Europe is one of the most surprising industrial achievements of the nineteenth century. It may be said to have grown up within the memory of men now living. For although in 1795 the Prussian chemist Achard presented several loaves of refined beet sugar to the King of Prussia, the enterprise was at once discouraged and abandoned. It was renewed, in France, in 1810. In 1814 it began to flourish, and in 1825 France produced 5000 tons of beet sugar. In 1837 the production had grown to 49,000 tons. By that time it began to attract attention in the United States. In that year Mr. Samuel Blackwell, a sugar refiner of Bristol, England, who had moved to New York in 1832, and, in connection with English capitalists, had put up in 1835 the first steam sugar refinery with vacuum pans ever erected in America, made some excellent loaf sugar from beets raised by him in his garden at Jersey City from imported seed.

Convinced by this experiment that beet sugar could be profitably

made by free labor in the United States, in competition with the West Indies and Louisiana, Mr. Blackwell moved to Ohio in 1838 for the purpose of engaging in its manufacture, but died a few weeks afterwards. Mr. David Lee Child, a little later, attempted its production in Northampton, Mass., and reported favorably, but failed to make it profitable. In 1861 Mr. E. T. Gamert attempted it on a larger scale in Chatsworth, Ill., but was unsuccessful. Small factories have worked with moderate success in Freeport, Ill., and in Fond du Lac., Wis., but have ceased to exist.

In California several factories have attained a certain measure of success. But these experiments have all been made with insufficient capital, and on a scale too small for profit. The great difficulty has been the want of sufficient beets at reasonable prices, their cultivation being almost unknown to American farmers. But during the last half century Europe has steadily developed the beet sugar industry. From 5000 tons of sugar in 1825, the annual product has become 1,500,000 tons, worth, at our present low scale of prices, about two hundred million dollars a year. More than one-third of all the sugar used in the world is now made from beets. Indeed, the progress of the industry is such throughout Continental Europe that it is predicted cane sugar will at no distant date cease to be used there.

In view of these facts, and of the vast sums annually paid by the United States for sugar and molasses—amounting to about one hundred million dollars per annum—the question arises, Why should not America make her own sugar from beets? Everybody knows that the beet grows luxuriantly in our soil and climate. The root contains as much sugar here as there. Against the cheap labor of Europe we have the advantages of cheaper land and cheaper fuel. Our farmers sell yearly to Europe other agricultural products—wheat, corn, cotton, cattle, cheese, etc., amounting to millions of dollars. Our sugar refiners are unequaled in skill and ability. Sugar is refined to-day more cheaply in America than in Europe. Why, then, do we not make our sugar? The answer is simply this: Everything must have a beginning. This is a new industry, unknown to the farmers who settled America. There is a great practical difficulty in changing an established system. Sugar is produced so cheaply by slave labor, and is imported on so large a scale, that it can only be profitably made on a great scale and with costly machinery. No capitalist will invest one hundred and fifty

thousand dollars in machinery to work beets that do not exist. No farmers will raise beets until a sugar factory is ready to buy them.

This almost impassable gap between the capitalist who cannot raise the beets and the farmer who cannot make the sugar, has at last been bridged by the Maine Beet Sugar Company, which last year made 183,000 pounds of beet sugar, is now erecting the best European machinery, and has contracted with 1700 farmers for 1250 acres of sugar beets. Under the stimulus of a State bounty of one cent per pound on the sugar produced, this company has leased the Forest City Sugar Refinery in Portland, Me., for the fall and winter months, and has expended a large sum in additional machinery. Next fall there is reason to believe that the experiment of making beet sugar in America will be fully and fairly tried in Maine. Indeed, the question will be reduced to this: "Can beets be raised by American farmers in quantities and at prices which will justify their conversion into beet sugar?" The result of the experiment will be awaited with general interest.—*Boston Advertiser.*

ON THE USE OF DETERMINING SLAG DENSITIES IN SMELTING.

By Thomas Macfarlane.

A paper read at the Pittsburgh Meeting of the American Institute of Mining Engineers, May, 1879.

In smelting copper, lead and silver ores, it is scarcely possible in every case to make analyses of the various parcels of ore, with the view of combining these and the fluxes, so accurately as to yield, in the furnace, slags of exactly the most favorable composition. This is even more difficult with ores which require previous calcination, or with mattes which have been roasted in heaps. Even in cases where the greatest pains have been taken and the most elaborate calculations made beforehand, it frequently happens that variations in the working of the furnace interfere with the result so much desired. Generally, the practical metallurgist must be content with ascertaining the average composition of his ores and fluxes, making a calculation once for all as to the most advantageous mixture, and leaving slight changes in its composition to be taken care of as it is passing through the furnace.

The various products then afford him the best material whereon to base his judgment as to the manner in which his smelting mixture and the furnace are working. Of course the character of the slag is one of his chief guides, but it is not always possible from its outward characters alone to form a correct judgment as to its composition. Neither would it be possible or practicable to apply chemical analysis for this purpose, as it would be impossible to wait for its results while working a furnace.

Abich was, I believe, the first to point out the relation existing between the composition of volcanic rocks and their densities, and to show that the latter being ascertained, very correct conclusions might be drawn as to their content of silica. The general rule is that the most siliceous rocks are the lightest, and the most basic have the highest specific gravity. It occurred to me that by determining the density of slags it might be possible to judge more accurately of their nature than by observing merely their superficial appearance. This plan was first applied at the Wyandotte Silver Smelting and Refining Works in September, 1877, when siliceous silver ores and galenas from Georgetown, Colorado, were being treated. Mr. F. H. Williams determined the following densities and silica contents of the slags from these ores:

Density.	Per cent. SiO_2.
3·44	37·6
3·48	36·35
3·50	36·3
3·51	35·8
3·56	35·15
3·57	33·90
3·63	31·15
3·88	30·40

In July and August, 1878, Mr. S. B. Wight made the following examinations of three slags from one and the same smelting campaign during which Western ores were being treated:

Sp. gr.	Per cent. SiO_2.	Al_2O_3.	FeO.	CaO.
3·47	35·05	Undetermined.	31·51	15·77
3·52	32·56	"	37·70	14·68
3·60	31·96	"	36·97	12·71

The gradual increase of density as the silica decreases in both these

series of examinations will be apparent. But the rule is not absolute, and is only applicable where the relative quantity of the different bases in a slag remains the same. In smelting ferruginous ores and lead and copper mattes the quantity of protoxide of iron in the slag in proportion to the other bases is usually greater, and this increases the density, although the percentage of silica may remain the same. A slag from smelting lead matte gave, on examination by Mr. S. B. Wight, as follows:

Specific gravity,	3·65
Silica,	34·67
Alumina,	14·85
Ferrous oxide,	39·04
Lime,	7·54

If this example is compared with the first in the last-mentioned series it will be found that an increase of 7·53 per cent. in the ferrous oxide, while the silica remains nearly the same, causes a considerable increase in density. The following determinations are further generally illustrative of the increase of density in slags as their percentage of silica decreases:

Where produced.	Sp. gr.	SiO_2.	Al_2O_3.	FeO.	CaO.
Iron Blast Furnace, Wyandotte,	2·85	55·	Undetermined.		
Copper Works, Detroit,	3·04	43·31	26·22	——	27·40
Germania Works, Utah,	3·81	28·01	Und.	48·10	12·37
Eureka Consolidated Works, Nevada,	4·18	26·47	"	61·62	2·73
Wyandotte Rolling Mills ("heating slag"),	4·29	25·49	"	75·06	——

Some of these determinations are by Dr. Hermann Hahn, others by Mr. S. B. Wight.

In practically making use of the slag densities for regulating the smelting at Wyandotte Silver Smelting and Refining Works, Jolly's spring balance (described at page 59 of Brush's *Determinative Mineralogy*) was found of great service. Five minutes only are used in making, by its use, two determinations of the density of a slag, and then it is found easy to decide whether any change in the smelting charge is necessary. The smelting of ore goes on regularly and cleanly when the specific gravity of the slag is kept between 3·6 and 3·8. Water-jacket furnaces are used, with six tuyeres, and a height from these to the charging-door of 12 feet. The crucible of each

furnace is 18 inches deep, and furnished with a tapping-hole at the bottom, besides the usual "lead-well" and slag-spout. The tapping occasions no difficulty, and so long as the slag is not allowed to become too heavy no incrustations are deposited in the furnace, which is easily cleaned out at the end of each campaign. The charging is managed in the following way: The smelting mixture is made up of ore and fluxes, and is calculated to yield a slag containing 32 per cent. silica. The slag necessary to keep the charge open is added separately in the proportion of about one-third of the smelting mixture. The slag used is unclean slag from previous campaigns and puddling slag or heating slag (*frischschlacke*) from the rolling mills. When the furnace yields a slag of greater density than 3·8 the proportion of rolling-mill slag is decreased. The latter is on the other hand increased when the slag produced is lighter than 3·6. By ascertaining the specific gravity of the slags frequently, and altering the charge in the manner described, the furnaces are found to work regularly and satisfactorily.

It is not supposed that the exact figures above given will be found of great value in other smelting works, or that by attending only to the composition of slags in smelting it will be possible to do the best of work. The metallurgist has very many points to consider at one and the same time while conducting smelting operations, and the object of this paper is merely to direct his attention to one of these points and to indicate a mode of ascertaining approximatively the amount of silica in slags with comparative ease and accuracy.

Transformations of Nervous Phenomena.—In reviewing the affections and the nervous phenomena which are propagated by a transmission and a transformation of motion, from simple yawning to epilepsy, fascination, panic, etc., J. Rambosson formulates the following general principle: A purely physical movement may be transformed into a physiological and into a psychic or cerebral movement by simple transmission to special portions of the system, and reciprocally, a psychic movement can be transformed into a physiological and into a physical movement by simple transmission to a different portion of the system, and that without losing its character; for it reproduces the same phenomena, after all these transmissions and transformations.—*Comptes Rendus.* C.

NOTE ON THE WEAR OF AN IRON RAIL.

By W. E. C. Coxe.

A paper read at the Pittsburgh meeting of the American Institute of Mining Engineers, May, 1879.

At a meeting of the Institute in Philadelphia, in June, 1876, it was my pleasure to read a paper on the "Manufacture and Endurance of Iron Rails." I then spoke of some trial rails which had been placed in the down track of the Philadelphia & Reading Railroad, over which passed, in addition to merchandise and passengers, most of the heavy coal traffic of that company. One of these rails, made at the Philadelphia & Reading Rolling Mill in 1870, and then placed in the track, was removed in 1876, after having carried about 55,000,000 gross tons, and was on exhibition at the Centennial Exhibition. A piece of this worn rail, twisted cold, was also shown there. One of the same series of rails was allowed to remain in the track until 1878, and short sections of this rail, as well as one not worn, to show its original shape, are presented for your inspection. A comparison of the two will show that the top of the head or tread has worn down $\frac{13}{16}$ths of an inch during its nine years of service. It carried in that time 67,000,000 gross tons of freight, passengers, cars and engines. This rail was made in the usual way of manufacturing iron rails at the Philadelphia & Reading Rolling Mill. The head was made from puddled iron bars, piled, heated and rolled into bars $4\frac{1}{2}$ and 3 inches wide by 1 inch thick, these bars breaking joints, heated and rolled into slabs 9 inches wide and 2 inches thick; the balance of the rail pile, which is in section 9 inches square, was made of $4\frac{1}{2}$ and 3 inch bars, rolled from two-thirds old rails and one-third puddled iron. This was heated and bloomed, and then reheated before rolling in two-high rolls into the finished rail.

The test-pieces from the head bar of this rail gave a tensile strength of 63,000 pounds. The borings from the head of the worn-out rail analyzed as follows:

Phosphorus,	·422
Carbon,	·027
Silica,	·392
Sulphur,	·032
Manganese,	·164
Iron,	98·963
	100·000

In making comparisons of the endurance or wearing qualities of iron and steel rails only the best of each kind should be taken, and the difference will not be nearly as great as has generally been assumed.

BOILER EXPLOSION.

A very disastrous explosion of a steam boiler occurred on the morning of June 27th, 1879, attended with the loss of life of the engineer and of a woman and two children, occupants of a house near the boiler house. The scene of the disaster was the planing mill of A. Wilts & Son, Nos. 721 to 727 North Front street in this city, where the boiler was in use for furnishing steam for the motive power (perhaps some 120 horse-power actual) of the planing mill.

The boiler itself was what is known to boiler makers in this vicinity as "a double-decked boiler," consisting of a lower horizonal cylinder, four feet six inches in diameter by twelve feet long, having 71 tubes, three and a half inches in diameter, spaced about one inch apart, thus filling this cylinder, except about four inches of water space and a man-hole space below the tubes completely. This lower cylinder was connected by four necks each one foot in diameter by about one foot long to an upper cylinder three feet six inches in diameter by fifteen feet long, over dished ends, and this again was joined by two necks, each one foot in diameter by about one foot long, to another cylinder or steam drum two feet in diameter by eight feet long over all.

The lower water line was supposed to be midway on the second of these cylinders, with gauge cocks (two above low water) about three inches apart. The boiler was made ten years since by Hunsworth & Naylor, of this city, from the best charcoal-hammered iron, and had been overhauled, furnished with new tubes and otherwise restored to the condition of what was thought equal to a new boiler six months since.

The joints were all single riveted. It had besides been examined with great care and tested by the officials of the Hartford Boiler Insurance Company, whose certificate or acceptation is equivalent to the city inspection according to law.

The destruction of the shell of the lower cylinder was very complete. One portion of horizontal joints about three feet in length (where a new sheet joined the old) only parted on the line of the joint, along the rivet holes of the old plate, while the waist of this shell was torn out diagonally across solid iron and on the lines of vertical seams, and the flattened plate of metal was hurled perhaps two hundred feet. The two heads were forcibly dished two or three inches by the resistance which the tubes offered to the explosion, one retaining all the tubes being driven against the brick work of the stack and setting at the back end, and the other was impelled across the street and lodged in the second story of a brick dwelling opposite. The remains of the engineer were found under this head. The upper portion of the boiler complete was torn off from the lower by the rupture of the four necks and thrown sidewise upon and demolished a frame dwelling near by. The woman and children killed were in this house.

Examination of the boiler after the explosion showed no deterioration apparent in the way of corrosion, and computation of strength gave adequate dimension for 80 pounds pressure of steam per square inch.

Test of the iron gave fair strength of material with perhaps some want of ductility not uncommon in charcoal bloom hammered iron made previous to the lawful tests for ductility as well as strength. The proportion and operation of the two safety valves were all that could be wished. The competency and carefulness of the engineer was maintained by all witnesses. No blame could be attached to any one with any fairness for the occurrence of this disaster.

This kind of steam boiler is peculiar to Philadelphia and its vicinity. Perhaps some 600 in all of them exist hereabout in use to-day, but they have met with no favor elsewhere. They are very economical as steam makers; they supply dry steam, they are easy to clean, to examine and to repair. The water line is very steady and well marked. But this is number five of them which within fourteen or fifteen years have exploded disastrously. The natural end of all boilers is to wear out; they show signs of decay, become leaky, are repaired, patched, caulked, finally after manifest imperfection they will be con-

demned and broken up. For one boiler that explodes destructively many hundred peaceably go out of existence.

The coroner's jury found "That the bursting of the boiler was the result of the use of an inferior quality of iron in the shell of the tubular boiler, conjointly with improper repairing and injudicious application of the hydraulic test."

STEAM ENGINES AT THE ROYAL AGRICULTURAL SOCIETY'S SHOW.

In the practice of Messrs. Marshall, Sons & Co., of Gainsborough, will be found much which will repay a visit to their stand. They exhibit no fewer than fourteen engines, of which two are vertical engines, two are traction engines, and two are horizontal stationary engines. The most attractive exhibit for engineers is one of the traction engines of eight horse-power. This engine embodies much that is new, and it is specially remarkable for the adoption of a singular device in connection with the valve gear, which illustrates very forcibly the difficulties which attend the reduction of theory to practice. It will probably be conceded without question that the more sensitive a governor is, the more uniform will be the speed of an engine. We suppose that to this there can hardly be a dissenting voice, yet in practice it is found that nothing can be much further from the truth. The traction engine in question has a single cylinder, 9¼ inch diameter by 12 inch stroke, and it is nominally of eight horse-power, and capable of working up to about forty horse-power, with 120 pounds of steam. The engine is intended for general use, and to drive a threshing machine among other duties. It is clear that if the ordinary reversing gear link motion could be combined with a governor much would be gained, the ratio of expansion being then determined automatically to suit the load on the engine. Hitherto all attempts to put this system in practice have failed, because the resistance of the ordinary slide valve is so great that no governor could properly control the link. Messrs. Marshall have got over this difficulty by substituting one of Church's patent balanced circular slide valves for the ordinary valve. Church's valves modified have been used by Mr. Webb, of Crewe, in locomotive practice, for some time, and Messrs. John Fowler & Co. applied them last year to ploughing engines. The resistance of the valve is so small

that it has been found possible by Messrs. Marshall to combine one of Hartnell's governors with the link. Hartnell's is one of the most sensitive governors in existence, and the result of the first experiments made with the combination to which we refer were far from satisfactory. It was impossible to keep the governor from hunting, with the result that although the engine made the same number of revolutions per minute, its rate continually altered during that minute. Thus ten or a dozen revolutions might be made at the rate of 150 a minute, while the ten revolutions preceding might be at the rate of 160, and the ten following at 140. The difficulty was finally overcome by putting a brake on the governor, which to a large extent renders it less sensitive, and it becomes an open question whether an ordinary slow speed governor would not answer far better. We may, while on this subject, add that Messrs. R. Garrett & Sons have found just the same difficulty with the cosine governor applied to an ordinary throttle valve, numerous adjustments having to be made to keep it from hunting. The bearing of this point on the electric light is of much interest. It is well known that equable driving of the Gramme or other electro-dynamic machine is of the utmost importance, to prevent flickering. At the same time it is a matter of comparatively small importance whether the machine is run at 700, or 750, or even 800 revolutions per minute. Heretofore engineers have always attempted to get perfectly uniform driving by using very sensitive governors, but there is reason to believe that these are precisely the governors which permit the greatest number of variations in speed. Let it be borne in mind that an increase or diminution in the speed of an engine producing the electric light of even a few feet of piston speed per minute in any one revolution produces a flicker, and it will be seen that a governor which may be perfect in the sense that half the load may be thrown off or put on without materially affecting the average velocity of the engine measured by the whole number of revolutions per minute, may be very defective in the sense that it permits the engine to make wide excursions above and below the average velocity, although such excursions last but a short time. Messrs Garrett inform us that they have sold a considerable number of engines for driving electro-dynamic machines abroad, all of which are fitted with common governors. They have never heard of any flickering in the light produced by such engines, but they cannot say so much of engines fitted with sensitive governors.

The matter is one well worth the consideration of electricians and engineers alike.

Returning to the consideration of Messrs. Marshall's practice, we may add to what we have already written concerning it, that in all their engines they now adopt the system of lining the cylinder. It is cast of the best cold blast iron, and then bored out, suitable internal projecting rings being left at each end. A second cylinder, cast of a very hard mixture, is then turned accurately to gauge on the outside, and forced into the outer cylinder by hydraulic pressure. The space between the two forms a steam jacket. The pistons are packed each with two cast iron plain rings, cut through diagonally and sprung into the recess in the piston body. They are forced out against the cylinder by a single spring ring inside as wide as both the packing rings together. The piston rings are cast of a mixture of Blaenavon, Parkhead and Gartsherrie iron, melted in crucibles in the brass foundry and such rings are found to wear admirably. In such practice as this we have an example of skill, forethought and resource which is certainly not exceeded in any other branch of mechanical engineering. As to the results obtained with the combination of the Church valve and automatic governor we shall speak fully when we illustrate the engine to which it is fitted. It must suffice to say now that the indicator cards obtained are very good, being identical with those obtained from railway locomotives when worked at various grades of expansion.

Messrs. Davey, Paxman .& Co. show an engine, among several others, in which automatic expansion is obtained in a very novel way. It may be remembered that at the Cardiff show, in 1872, this firm sent a portable engine for trial, which gave an excellent duty. It was the first racing engine ever made by the firm, and had not a crank shaft bearing been screwed down too tight, and heated in consequence, it would have made one of the best performances on the brake on record. Its mechanical time was 4 hours 18·17 minutes, and its consumption of fuel but 3·23 pounds of coal per horse per hour. The boiler evaporated 9·97 pounds of water per pound of coal, or about 1·33 pound less than that of the first-prize engine, or say 11 per cent. less. Had the boilers been equally efficient, Messrs. Davey, Paxman & Co.'s engine would have made over 4¾ hours mechanical time. This excellent performance was due, in large measure, to the use of a gridiron cut-off valve worked by a double cam on the crank shaft. The expansion curve obtained by this means was nearly perfect, indeed no better

diagrams were obtained. There were certain drawbacks to this method of driving a cut-off valve—although we may add that since 1872 the Cardiff engine has done a great deal of work, with much economy, the valve gear giving no trouble. In the engine exhibited, Mr. Paxman has retained the good features of the gridiron cut-off while getting rid of the cam. The engine is twelve horse-power, horizontal, of the girder type. The arrangements for setting up the crosshead bearings and those of the crank shaft are very ingenious and well worked out. The valve gear consists of an ordinary slide valve with full travel and very little lap or lead. It works as close as possible to a partition, in the same plane, in the valve box. In this partition are made three ports, and over them slides a gridiron valve, which is the cut-off valve, as no steam can get to the main, or distributing valve, without passing first through the ports in the partition before mentioned. The cut-off valve is driven in the following way: On a stud in the frame revolve two small eccentrics pinned to a toothed wheel, the rods of these eccentrics actuate a link uniting their ends, and this link drives the spindle of the cut-off valve. On the crank shaft is keyed a wheel just twice the diameter of that carrying the eccentrics, which last, accordingly, makes two revolutions for one of the engine. The eccentrics are called positive and negative, and are so set that while one tends always to keep the cut-off valve open the whole time a steam port is open, the other tends equally to keep the gridiron ports shut whenever a main steam port is uncovered by the slide valve. According to the position of the link, one or other will have most control over the cut-off valve. A high speed governor of the Porter type is connected direct to the end of the link, and shifts it to any required position. We have seen this engine under steam and its action was in every way satisfactory; the wheels being carefully cut, run practically without noise; the governor acts freely. There is no complication of parts, and altogether this may perhaps be regarded as one of the most satisfactory automatic expansion gears of the many which have been brought out of late years, while the engine, taken as a whole, is strong, neat and serviceable.—*The Engineer.*

China claims the Telephone.—The Pekin *Official Times* publishes a communication from a Chinese savant, asserting that the telephone was in use A. D. 922, and that it was invented by a citizen of Pekin.—*Fortschr. der Zeit.* C.

A NEW HARMONOGRAPH: INDUCTION BALANCE.

Mr. W. J. Wilson exhibited before the Physical Society, May 24th, a new harmonograph and figures drawn by it. The figures drawn by prior harmonographs are all more or less imperfect owing to loss of motion in the pendulums actuating the marking pen; and Mr. Wilson therefore designed a new harmonograph which not only gives perfect figures but admits of the phase of either of the two compounded motions being decreased by a known amount. In this instrument toothed wheels take the place of pendulums, the ratio of the teeth giving the ratio of the periods of the motions. By employing the device of an intermediate wheel gearing with two others, and arranging two or more wheels on the intermediate axle, a great variety of phase can be obtained for each motion. An ingenious adjustment by means of a movable nut allows the phase of either or both motions to be altered to a known extent, and thus an endless variety of figures can be obtained. As in other harmonographs a writing-table on which the paper is placed, and an aniline glass pen, are used. Several of the figures done also on glass were thrown on the screen, the stereoscopic effect being very apparent. In reply to a query Mr. Wilson said that he had adapted some of the figures to the stereoscope. Prof. Hughes explained his new induction balance and showed some of its principal effects. It is well known that on starting an electric current along a wire adjacent to another wire, an induced current is set up in the second wire in an opposite direction to the first or primary current. In the induction balance two primary circuits or coils are taken, with the same current (interrupted by a microphone acted upon by the ticking of a clock) running through both; and between these is placed a secondary circuit or coil in connection with a telephone. The primary coils are so wound as to oppose each other's induction on the intermediate secondary. There is a point, moreover, between these, where these opposed inductive influences exactly neutralize each other. If the secondary coil be placed there, no induced ticking of the clock can be heard; but if the secondary be displaced to one or other side of this point, the ticking can be heard in the telephone increasing in loudness as the secondary approaches one or other of the primaries. If the distance between the primaries be graduated into a scale, this contriv-

ance becomes a sonometer, since it gives an absolute zero of sound, and degrees of loudness. It is well adapted for measuring the hearing power of the ear. By splitting the secondary coil into two parts and placing each close to its proper primary, so that there are four coils in all arranged in two pairs, the extremes in one primary circuit, and the means in one secondary, the two opposing parts of the balance can be separated from each other, so as not to disturb each other's action, and the balance made very sensitive by the closeness of the primaries and secondaries. Prof. Hughes finds that there is a line or zone of maximum induction midway between each primary and its secondary. If a conductor, such as a piece of metal, be put in this position, it has a maximum disturbing effect on the balance, due probably to the electric currents generated in it by the induction. The effect is apparently proportional to the conductivity of the metal. It requires an exactly similar piece of metal put between the other pair of coils to restore the equilibrium of the balance. A difference of alloy, or of weight between two like coins is at once observed from the imperfect restitution of the balance; base coins are thus also at once detected. Again, it is possible for a person to tell what particular coin or coins are in one part of the balance by trial of the same coin in his part. When plates of non-magnetic metals are held vertical in the balance their disturbing effect is *nil;* iron on the other hand gives its maximum effect on this position, because its magnetic effect overbalances its electrical effect. Two pieces of iron may therefore neutralize each other as cores in an induction coil. Steel is easy to balance compared with soft iron. Zinc disturbs most when placed along the sides of each pair of coils; iron when in centre at a certain length of metal laid along the outsides of the coils produces silence. The maximum line of inductive force is midway between the coils, and there is a line of minimum force at half the thickness of each coil. A metal placed at these lines of minimum force has no disturbing effect on the balance. Pressure applied to small shot, or spongy gold, alters the balance. The effects of stress, heat, magnetism, light, etc., on matter could be determined by the balance. Prof. W. G. Adams believed that one result of Prof. Hughes' experiments will be the determination of the way in which the law of electro-dynamic induction depends on density. He also imagined that the metal when in the maximum line between the coils gathered the lines of force to itself, whereas when on the minimum lines it could not thus divert them. Prof. Ayrton cited the early

experiment of Faraday with a sheet of copper oscillating to rest between two opposite magnetic poles. The copper took a long time to stop; but a sheet of iron placed between two like poles was soon stopped owing to its becoming imbued with an opposite polarity, and deflecting the lines of force. He also suggested that the divergence of the results for conductivity of metals got by the induction balance from those got by the Wheatstone balance might be due to that electric inertia suspected by Sir William Thomson. Prof. Guthrie thought that the induction balance pointed to the conclusion that the disturbing effect of a conducting mass applied in this way is proportional to the quantity of electricity generated in it under certain conditions of temperature, etc. The determination of the conductivity of liquids, would be a useful application of the balance. Mr. Chandler Roberts gave some results which he had obtained from an examination of certain alloys by means of the induction balance. He had been able to detect a difference of one part in 1000 in the amount of silver in two shillings of equal weight. He also pointed out that Mathiessen divided alloys into three classes: (1) solidified solutions of one metal in another; (2) solidified solutions of one metal in an allotropic modification of another metal; (3) solidified solutions of allotropic modifications of both metals. For the first class the curve of electric conductivity is a straight line, for the second a parabolic curve, for the third a bent line. Mr. Roberts found that the balance gave the characteristic curve for the first class with an alloy of lead and tin, and for the second with an alloy of gold and silver. With a copper tin alloy, which is a good example of the third class, he found the curve given by the balance to be intermediate between Alfred Risch's curve of density and Mathiessen's curve of conductivity, and considers that the balance is influenced by the density as well as the conductivity of the metal interposed. Prof. Hughes said that as the working of metals appeared to affect their conductivity he was inclined to rely more on the conductivity measurements of the balance than on those of the Wheatstone bridge. By the balance plain pieces of metal were taken, whereas by the bridge wires were mostly taken. He would rather not give any theory yet as to the results obtained from the balance. Dr. Erck then exhibited his novel pump for lifting solutions out of batteries. It consists of a closed vessel, funnel-like, the stem dipping into mercury, a column of which ascends the latter to a certain height.

Two tubes emerge from the cover, one dipping into the liquid, the other opening to the air. By altering the pressure inside the vessel the solution rises to the latter, and can escape from it by trickling through the mercury.

AN ALARM COMPASS.

A very ingenious application of electricity to the purposes of navigation has recently been effected by Mr. Henry A. Severn, of Hernehill, who has succeeded in producing a mariner's compass which enables the captain or officer in charge to hear, by the ringing of a bell, when the vessel is out of the ordered course. In the construction of this compass Mr. Severn has availed himself of the constant position of the card and the ever-varying position of the ship for the purpose of making and breaking metallic contact, which causes an electric bell to be sounded, and thus to announce the fact that the vessel is off her course. The whole of the apparatus is contained in a small box, which is easily carried about, and is intended, as a rule, to be placed in the captain's cabin. Over the card are two index hands, which can be adjusted to any angle allowing of greater or less deviation in steering to either the port or starboard side.

Assuming the captain, on quitting the deck, to have given instructions to steer the ship on a certain course, he sets the index hands to a certain angle, allowing the steersman a given latitude for deviation either to port or starboard of that course. Instead of having to be constantly watching the compass, as at present, to see that his orders are carried out, the captain leaves the instrument to tell him by its silence if they are, and by its sounds if they are not, obeyed. Should the ship be steered off her course beyond the limit allowed on either side, an electric alarm bell rings instantaneously, and moreover continues ringing until the right course is resumed. The index hands can be raised away from the card, when the bell becomes disconnected and the compass can be used like an ordinary one.

The means whereby this useful result is attained may be thus briefly stated. The metal point upon which the card is hung is insulated from the compass bowl, and to it is attached a wire from one pole of a small battery. About an inch above the card, placed parallel to its surface and attached to its metal centre (which is insulated from the

needle), is an arm of metal reaching nearly to the edge of the card. This arm is therefore in metallic communication with the wire from the battery already referred to. The glass lid of the compass has a short brass rod working within a tube passing through it. These are severally attached to two brass milled heads above the glass lid, and to the two movable index hands beneath the glass. These are in metallic contact with the brass-work of the compass, and this with the other pole of the battery. Beneath the outer extremities of the index hands are suspended two pieces of platinum wire about three-quarters of an inch long. These hands can, by means of the two milled heads, be moved round to any position over any point of the card. Hence they admit of being placed on either side and equally distant or otherwise from the end of the metal arm on the card.

It will thus be seen that whenever the platinum wires come into contact with the metal arm on the card the circuit is completed. The electric bell being placed in the circuit sounds whenever such contact takes place. The bell is disconnected by simply raising the the milled head up half an inch through a sliding tube, and the compass then becomes in all respects an ordinary one. Two bells of different tone can be used, and thus the instrument will indicate to the captain whether the deviation in steering is to port or starboard. The arrangement is simple and compact, and the invention promises to subserve a very useful purpose in navigation. By its use the captain will be saved much anxiety, and the knowledge that there is a check upon them will serve to render officers more vigilant and steersmen more careful. Headlands and rocks may thus be guraded against with much greater security, while in the case of vessels riding at anchor in a port or road, this compass will at once give intimation of swinging —a matter of importance, especially at night, when many vessels are together. In short, the dangers of navigation generally will be considerably lessened by its use.

Economy of Electric Carbons.—M. Delaurier says that by guarding the poles of the electric circuit from air currents, an atmosphere of carbonic acid may be formed around them, which prevents useless waste and greatly diminishes the cost of lighting by electricity. —*Les Mondes.* C.

AUTOTYPES.

For about ten years a process of photographic printing yclept "autotype" has been growing into notice, and asserting its right to occupy the field of art photography. It not only claims to have solved the problem of rendering the photographic image inalterable, but by the command of a wide range of monochromic effect, and of different surfaces for the reception of the picture, to have rendered practicable the reproduction of an artist's work in fac-simile. For example, an artist expresses his ideas in charcoal, in crayon, in sepia, or red chalk; the process is able to replicate his work, the same size, or larger, or smaller, employing the pigment of the original and the same kind of paper or foundation. The copy in such case may reasonably be believed to be as permanent as the original. A drawing or other artistic work reproduced by ordinary photographic means is palpably but a photograph: printed in autotype it will be so close a fac-simile of the original as not easily to be distinguished from it.

The autotype thus claims under favorable circumstances to reproduce the very body and soul of an artist's work—his touch and sentiment, with the actual pigment of his palette and the material he works upon. Effecting this by chemical means without the intervention of another hand, the process found a sponsor to name it autotype.

The starting point of all photographic pictures is the production of a negative in the camera. The negative becomes a matrix of endless prints. Most of our readers are familiar with a negative, and have noticed how the lights and shadows of the image on the glass are reversed; the high lights of the subject being represented by a dense deposit, while its shadows approach the condition of clear glass. It follows that light will be retarded in its passage through a negative exactly in proportion to the varying density of the image on its surface, and the art of photographic printing consists in providing that the transmitted light shall impinge on a surface sensitive to its impression. This has hitherto been effected by the use of a paper coated with a thin stratum of albumen and rendered sensitive to light by a salt of silver. Photographs so produced are liable to gradual spontaneous decay, and fade away to the pale ghosts of their former selves, and ultimately disappear.

Autotypy claims permanency for its raison d'etre. The difference it imparts into photographic printing consists principally in substituting for the fickle salts of silver some permanent pigment as the physical basis of the picture. This substitution not only supplants the evanescent by what is practically inalterable, but endows photographic art with the wide range of monochromic effect. Photography in natural colors is still a dream, but autotypy is able to make some slight advance towards art in this direction. The process is founded on the property of gelatine when combined with a bichromate salt to become insoluble in water after having been exposed to light. Paper is coated with a film of liquid gelatine containing finely ground color and sufficient of the bichromate salt to insure chemical action. This sensitive tissue, kept from the light, is perfectly soluble in water; but if light acts upon it the whole condition is altered: the gelatine becomes insoluble, and firmly imprisons every particle of the coloring matter. It will now be understood that if this sensitive tissue be placed under a negative and exposed to light, the chemical action exerted upon it will be in proportion to the density of the negative; where much light passes, the tissues will be deeply penetrated and much color imprisoned; where the light is partially intercepted less color will be fixed, and a latent picture will be formed in the tissue in exact gradation, and with the lights and shadows as in nature.

To make this latent picture visible, it is, in technical language, "developed" by the action of warm water, washing away such portions of the colored gelatime film as have not been influenced by light. But effective development is only possible by an ingenious operation known as "transfer." The impact of light through the negative on the surface of the tissue has rendered that surface insoluble, and to achieve success the pictorial film must be attacked at the back, that is, at the surface resting on its paper support. The various methods of effecting this constitute an important part of the autotype patents.

The sensitive tissue which under the negative becomes fecundated by light is called the "temporary support," and the surface of this is made to adhere by pressure to the material on which the picture shall finally remain. This "permanent support" may be drawing paper, canvas, panel, ivory, or, in fact, almost any material used by artists. The two adhering supports are immersed in warm water, which softens the gelatine and allows the original paper or temporary support to be peeled off, and thus lays bare to the action of the water all the pig-

mented gelatine unaffected by the light. Under the solvent action of water the picture gradually appears and remains firmly adherent to its support. The lights and shades of this picture are built up by various degrees of thickness in the gelatine and pigment, representing exactly the gradations of density of the original negative and the consequent modifications of the action of light. The developed pictures, after being immersed in a solution of alum, washed in pure water and hung up to dry, are trimmed and mounted in the usual way. Such photographic pictures consist of particles of pigment held together by an incredibly thin film of gelatine, rendered insoluble by chemical agency. —*Art Journal.*

Causes of Injury to Cables.—The teredo has been very destructive in its attacks upon the gutta-percha coating of submarine cables. Sharp-toothed fishes have often interrupted the communication between Cayenne and Para. Turtles have attacked the wire from Key West to Havana. A whale broke the cable in the Persian Gulf, and lost its life by getting entangled in the wire. Lightning has destroyed one or two of the Mediterranean cables. In some places submarine currents have worn out the cables by friction against the rocks; in others they have broken by their own weight in spanning ocean valleys. The attacks of insects have been partially overcome by mixing poisonous ingredients with the gutta-percha.—*L'Electricité.* C.

New Pendulum Experiments.—M. Dejean de Fouroque has experimented with a pendulum, vibrating in a large arc and free to move in all azimuths. He finds that the plane of oscillation tends rapidly to assume a special direction, which is, according to his views, the horizontal projection of the earth's trajectory, or, in other words, the resultant of the two great movements towards the constellation Hercules and around the sun. The path traverses the meridian four times a day, and the hours of crossing vary with the position of the earth in the ecliptic. M. A. Corwin has witnessed the experiments and reported them to the French Academy. Although he hesitates to adopt Fouroque's conclusions with regard to the cause of the movements, he thinks them so interesting and important that he recommends them to the careful study of physicists and geometricians.—*Comptes Rendus.* C.

Fossil Oak.—A sunken oak forest, of great extent, has been lately discovered in the neighborhood of Rothenburg, on the Fulda, in Hesse-Cassel, from two to three meters (6·562 to 9·843 ft.) below the surface. It appears to have been submerged in prehistoric times, in consequence of heavy freshets on the Fulda. Some of the trunks are of truly colossal dimensions. The wood is coal-black and extraordinarily hard. —*Fortschr. der Zeit.* C.

The Navisphere.—M. de Magnac has submitted to the French Academy an instrument for navigators, to which he gives the name of navisphere. It shows the stars which are above the horizon at any given moment, and determines their altitudes and azimuths within about 1°. It also shows, with the same approximation, the proper course for great-circle sailing from one point to another, and the distance between those points within about ¼ of 1°. It gives a ready practical solution of spherical triangles. It has been tried upon the *Washington*, of the Transatlantic Company, with such favorable results that it seems likely to come into general use. [It would be interesting and desirable to subject it to comparative tests with Dr. Thomas Hill's Nautrigon.]—*Comptes Rendus.* C.

Transmission of Force by Electricity.—In an extended communication "On the transmission and distribution of motive power to a great distance by means of electricity," M. A. Achard cites experiments of MM. Higgs and Brattle, and of E. Hagenbuch-Bischoff, Professor of Physics in the University of Basle. The gentlemen first named used Siemens' machines, and found a maximum efficiency of from 39 to 49 per cent. when the rotating velocity of the receiver was about half as great as that of the generator. M. Hagenbuch-Bischoff experimented with a Gramme machine, and reported efficiency of from 65·9 to 93·5 per cent., the force being increased by the aid of a brake, a method which Achard thinks objectionable. He recommends systematic experiments for the following purposes: 1. To ascertain, for many types of induction machines, and for the principal varieties of each type, the relation between the intensity of the current and the magnetism of the induction magnets, and to seek an empirical formula for representing the relation. 2. To determine the rendering of the different induction machines when acting as generators. 3. To determine the rendering of the same machines when acting as motors.—*Ann. des Mines.* C.

Sinus-Manometer.—Julius Thomsen, of the University Laboratory in Copenhagen, has contrived a new manometer for the measurement of slight differences of pressure, to which he gives the above name, because the difference of pressure is proportional to the sine of the angle of deviation in a small pendulum. By its aid it is easy to observe a difference of a difference of pressure equivalent to a column of air 1 millimetre (·039 in.) high, or of a column of water $\frac{1}{770}$ of a millimetre ($\frac{1}{19600}$ of an inch) high, a degree of delicacy hitherto unknown. It can also be employed as a gas regulator, or as a governor of ventilating currents.—*Ann. der Phys. u. Chem.* C.

Prediction of the Microphone.—In her work on the "Physical Basis of Immortality," published in 1876, Antoinette Brown Blackwell said: "It remains to invent some instrument which can so retard the too rapid vibration of molecules as to bring them within the time adapted to human ears; thus we might comfortably hear plant movements carrying on the many processes of growth, and possible we might catch the crystal music of atoms vibrating in unison with the sunbeams. Sound can be refracted by passing it through a lens which retards its motion. Such an improvement upon the stethoscope would reveal phenomena but little more marvellous than those already offered us by the telescope and microscope."—*Woman's Journal.* C.

Electro-magnetic Tests of Steel.—Dr. A. von Wattenhofer presented a communication to the Vienna Academy in 1863, in which he gave an empirical formula for the relation between the strength of a magnetizing current and the resulting magnetic moment of a steel rod. The formula contained a coefficient which furnished a ready means for estimating the hardness of any given sample of steel. In 1878, A. von Kerpely criticized the theory and methods, but without sufficient care in his experiments. Von Wattenhofer, in his reply, describes a delicate balance (which can also be readily used for weighing letters), and shows the importance of maintaining constancy of current. In all comparisons it is necessary to have all the circumstances as nearly alike as possible, and to avoid any initial or residuary magnetism in the rods which are subjected to trial. If proper precautions are observed, he claims that the results will be more consistent and satisfactory than can be obtained in any other way.—*Dingler's Journal.* C.

SCIENTIFIC SPECIALTIES.

VIENNA ACADEMY OF SCIENCES, Jan. 16, 1879. Pre-historical investigations in Lower Austria, Carniola and Bohemia, by F. v. Hochstetter.

ROYAL SOCIETY, London, May 29. Note on the spectrum of sodium, by J. Norman Lockyer. The metal, after slow distillation in a vacuum for some time, shows the red and green lines without any trace of the yellow one. Hydrogen is given off in large quantities; and at times the C line and the red "structure" are seen alone. After this treatment the metal, even when red hot, volatilizes with great difficulty.

LINNEAN SOCIETY, May 1st. A paper by Thomas Meehan gives observations from which he deduces the conclusion that the struggle for power between the vegetative and the reproductive forces decides fertility.

ANTHROPOLOGICAL INSTITUTE, May 13. Ethnology, mythology and philology of early civilized races, by Hyde Clarke.

FRENCH ACADEMY, May 26. Refraction of obscure heat, by M. Desains. Determination of calorific wave lengths, by M. Mouton.

IMPERIAL ACADEMY OF SCIENCES, Vienna, March 20. Relation between heat radiation and temperature, by Prof. Stefan. Chemical composition of pyroxilin and formula of cellulose, by Prof. Eder. April 3. Polar actions of the electric current in striated muscle, by Prof. Hering. Ditto, in muscles deprived of nerves, by Dr. Biedermann.

ROYAL SOCIETY, May 15. Capillary phenomena of jets, by Lord Rayleigh.

FRENCH ACADEMY, June 2. Ultra violet limit of the solar spectrum, by M. Cornu. Production of Widmanstaetten figures on artificial iron, by Prof. Lawrence Smith.

MONITEUR SCIENTIFIQUE, June, 1879. Influence of change of temperature upon the deviation which inverted sugar produces upon polarized light, by Paul Casamajor. Acceleration in the tanning of hides by means of phosphoric acid, by E. Ador. Use of anhydrous chloride of calcium for preserving steam boilers, by M. Burstyn.

CHEMICAL SOCIETY, June 5. On chlorstannic acid, by J. W. Mallet. A bottle containing a strong solution of stannous-chloride, after standing for a year, deposited a transparent jelly-like substance, which proved to be SnO_2HCl.

PHYSICAL SOCIETY, May 24. New induction balance, by Prof. Hughes.

AMERICAN ACADEMY OF ARTS AND SCIENCES, May 14. Two new proofs of the dimensions of molecules, by N. D. C. Hodges. New form of photometer for measuring the light of a nebula or comet by comparison with a star thrown out of focus, by Prof. Pickering. The method employed eliminates the effects of moonlight or twilight. New method of studying wave motion and vibrations on the surface of mercury, by Prof. John Trowbridge.

GEOLOGICAL SOCIETY, June 11. Further discoveries in the Creswell caves, by Boyd Dawkins and J. M. Mello.

PHYSICAL SOCIETY, June 14. Plan for suppressing the induction disturbances in a telephone circuit, by Prof. Macleod. Experiments on the sensitiveness of electric discharges in vacuum tubes, by Moulton and Spottiswoode. Traces of oxygen and carbon in the sun, by Dr. Henry Draper and J. Norman Lockyer. Mr. Lockyer congratulated solar science on having so able a worker as Dr. Draper.

FRENCH ACADEMY, June 16. Influence of media on the structure of roots, by M. Mez. Modifications in the apparent color of flowers by the electric light, by M. Hugo.

SILLIMAN'S JOURNAL, July. New form of spectrometer, and distribution of the intensity of light in the spectrum, by J. W. Draper. Progress of experiments for comparing a wave-length with a metre, by C. S. Peirce.

LONDON E. AND D. PHIL. MAG., July. New theory of terrestrial magnetism, by Profs. Perry and Ayrton. On electric boundary layers, by Prof. Helmholtz. (From the February Monatsbericht of the Berlin Academy.)

DONATIONS.

Annales du Génie Civil, ou Receuil de Memoires sur les Ponts et Chaussées, etc. Paris: E. Lacroix, 1862 to 1871 inclusive. 28 vols. Plates. From Lewis S. Ware.

Souvenirs de Marine Conservés, ou Collection de Plans de Navires et de Bateaux de tous les pays. Par l'Amiral Pâris. 1877.
From the Author.

Annual Report of the Chief of Engineers. 1878. In three parts.
From the Chief of Engineers.

Chronological History of Plants. By Charles Pickering. Boston, 1879. From Mrs. S. S. Pickering.

Fiftieth Annual Report of the Board of Commissioners of Public Schools of Baltimore for 1878.
From H. E. Shepherd, Sup't of Instruction.

Improved Dwellings for Laboring Classes. Pamphlet on.
From R. Grimshaw.

Memorial Address upon the Character of Morton McMichael. By J. W. Forney. From the Author.

Crofutt's New Overland Tourist and Pacific Coast Guide.
From E. A. Crofutt.

Mechanical Refrigeration. Part 14. By J. J. Coleman, of Inst. of Engineers and Shipbuilders in Scotland. Glasgow, 1879.
From the Author.

Abstracts of Papers in Foreign Transactions and Periodicals. Excerpt Min. of Proceedings Inst. of C. E. London, 1879.
From the Institution of Civil Engineers.

Equatorial Fundamental Stars. By S. Newcomb. Washington, 1872. From the U. S. Naval Observatory.

Specifications and Drawings of British Patents. Vols. 13 to 21 and 23 and 24. Nos. 1201 to 2100; Nos. 2201 to 2400. March—June, 1878.

Alphabetical Index of Patentees and Applicants for Patents of Invention for the Year 1878.

Abridgments of Specifications relating to Purifying and Filtering Water. Part 2. 1867—1876. Also,

Agriculture. Div. 2. Barn and Farmyard Implements. 1636—1866.

Disclaimers and Memorandums of Alterations. No. 2520, of 1867; No. 3437, of 1869; Nos. 279, 861 and 3761, of 1875; Nos. 1900 and 4824, of 1877.

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